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The Interface Between Reading and Nonreading Characteristics of Subgroups of Disabled Readers

University — Université
University of Alberta

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée
Doctor of Philosophy

Year this degree conferred — Année d'obtention de ce grade 1983	Name of Supervisor — Nom du directeur de thèse DR. Lillian Whyte

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The Interface Between Reading and Nonreading Characteristics of Subgroups of Disabled Readers

by

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A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF Doctor of Philosophy
IN
Special Education

Department of Educational Psychology

EDMONTON, ALBERTA
Fall 1983

THE UNIVERSITY OF ALBERTA

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DEGREE FOR WHICH THESIS WAS PRESENTED Doctor of Philosophy

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Date...May..27,.1983........

Dedication

To Byron,
who gives special meaning
to my life
and to all that I do.

Abstract

The central problem addressed in the present study involved the interface between reading and nonreading characteristics of subgroups identified within a public school sample of 9- and 10-year-old children who manifested difficulty in reading. Both reading and nonreading characteristics were assessed within a multiple-syndrome paradigm. The assessment included: quantitative and qualitative analyses of oral reading sensitive to strategies used in reading connected text; standardized tests of word identification, word attack and passage comprehension; a qualitative analysis of the phonetic accuracy of spelling errors; measures of IQ, language, memory, sequencing, perception, visual-motor and motor functioning; and teachers' ratings of classroom behaviour and arithmetic achievement.

Objective statistical classification procedures (Q factor analysis and Ward's cluster analysis plus a relocation procedure) were applied to reading data and to nonreading data, respectively. The results indicated that subgroups of disabled readers could be formed on the basis of reading characteristics and on the basis of nonreading characteristics. Overall, more satisfactory classification solutions were obtained for reading data than for nonreading data, and cluster analysis was preferred over Q factor analysis.

Four subgroups were formed by Q factor analysis of reading measures. However, coverage was low (33 of 49 subjects were classified), many subjects had high negative factor loadings and several subjects loaded highly on more than one factor.

Cluster analysis of reading measures yielded four subgroups which were stable under relocation and which had internal validity demonstrated by data manipulation, graphic presentations, and statistical tests. All 49 subjects were classified in four subgroups: 1) least proficient (n=11); 2) context cue users, poor comprehenders (n=12); 3) grapho-phonic cue users (n=13); and 4) high comprehenders (n=13). External validity assessed by analyses of variance of nonreading measures was weak with only four significant differences among the subgroups. All subgroups appeared to have low level linguistic deficits but varied in the degree of involvement of sequencing deficits and higher level linguistic deficits.

Statistical classification procedures were applied to nonreading data with less success. Q factor analysis did not yield interpretable subgroups. Five subgroups were formed by cluster analysis of four factors from an R factor analysis of nonreading measures. Internal validity was weak under data manipulation, but graphic presentations and statistical tests confirmed the distinctiveness of the five subgroups: 1) relatively good performance on the four factors, namely, Verbal, Auditory sequencing, Spatial/visual-motor, and Memory/sequencing; 2) low Memory/sequencing; 3) low Verbal, high Auditory sequencing; 4) low Spatial/visual-motor, high

Verbal; and 5) low Auditory sequencing. External validity against reading measures was weak. Trends indicated relationships between auditory sequencing skills and the speed and accuracy of using grapho-phonic cues for word identification, and between higher level linguistic skills and reading comprehension.

Different subjects tended to be grouped together by the classification analyses of reading data compared with those grouped together on the basis of nonreading characteristics. The correspondence observed among the subgroups suggested that high comprehension was related to relatively unimpaired nonreading test performance and auditory sequencing skills were related to the grasp of spelling-sound correspondence rules.

Acknowledgements

Sincere appreciation is extended to my supervisor, Dr. Lillian Whyte, who has played an important role throughout my Ph.D. program. I am grateful for her advice, guidance and support, and particularly for the time she has made available to me.

I would like to extend special thanks to Dr. Robert Bornstein for his friendship, encouragement and advice, and to Dr. Marian Jenkinson for her stimulating comments. The valuable input and assistance of Dr. Lorraine Wilgosh and Dr. Carolyn Yewchuk, members of my examining committee, are also gratefully acknowledged. I would like to thank Dr. Donald Doehring, my external examiner, whose insightful and positive comments were both stimulating and challenging.

I owe a debt of gratitude to the principals, teachers and students whose cooperation contributed to the successful collection of the data for the present study.

I would also like to express my appreciation to my husband, Byron, to my family and to my friends, particularly Corinne Callan and Dr. Robert Mulcahy, whose understanding and encouragement were always available, and frequently needed.

Two sources of financial assistance contributed to the successful completion of the present study: a Social Sciences and Humanities Research Council Doctoral Fellowship and a University of Alberta Dissertation Fellowship.

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I. Introduction

Professionals from many disciplines including education, psychology, neuropsychology, linguistics, and medicine have been seeking to understand the unexpected failure to learn to read by a child whose:

> Intelligence level, oral language development, and sensory capacities appear to be fully adequate to permit the development of reading skills; who has had the benefit of conventional classroom instruction in reading; and who at the beginning of schooling had normal motivation to learn to read (Benton, 1975, p.2).

Children who encounter reading problems of the nature described above are subsumed under the label "learning disabilities", a term which came into use in 1963. Prior to 1963, the varieties of learning disabilities were divided into three categories: disorders of spoken language, disorders of written language, and disorders of perceptual and motor responses. The initiation of a field of learning disabilities and the use of the term learning disabilities resulted in a tendency to lump together children who manifested a variety of learning disorders. The heterogeneity of the children encompassed by the term is obvious in the following excerpt from a definition put forth by the United States National Advisory Committee on Handicapped Children (1967):

> Children with special learning disabilities exhibit a disorder in one or more of the basic physiological

> processes involved in understanding or using spoken or written language. These may be manifested in disorders of listening, thinking, talking, reading, writing, spelling, or arithmetic.

The label "learning disability" has been used synonymously with a variety of terms which include perceptual disability, minimal brain dysfunction (MBD), hyperactivity, developmental dyslexia, developmental dysphasia, and reading disability. The term tends to be over-inclusive. Variations among learning disabled children have been ignored and the learning disabled population has been treated as homogeneous. Lumping together children with diverse problems led to research characterized by a search for a unitary explanation which would account for all learning disorders. However, no satisfactory explanation has been found. Inconsistent and contradictory research findings abound in the field of learning disabilities.

Researchers are responding to the need for clarification by showing greater awareness of the diversity of learning disabilities and of the need for more complex models corresponding to the complexity of the problem (Satz & Morris, 1981). There is a movement towards greater refinement of classification systems for identifying subtypes of learning disabilities (e.g., Frith, 1980; Ingram, Mason & Blackburn, 1970; Nelson & Warrington, 1974; Rourke, 1978; Rouke & Finlayson, 1978; Satz & Morris, 1980; Spellacy & Peter, 1978).

Similar developments may be traced with regard to reading disorders within the broader field of learning disabilities. Terms used to describe unexpected reading failure include reading disability, specific reading disability, dyslexia, developmental dyslexia, specific developmental dyslexia, and specific reading retardation. Many definitions have been used without regard for the resulting differences in the samples of disabled readers under study (Appelbee, 1971). Exclusionary criteria characterize the definitions and contribute to variability that is frequently ignored. Definitions vary in the number of exclusionary criteria included, in the severity of the reading deficit, the aspect of reading assessed (e.g., silent reading comprehension vs. recognition of isolated words), the IQ criteria, the sex distribution and the specification of associated academic problems.

Until recently, the heterogeneity of reading disorders was ignored and research followed a single-syndrome paradigm (Doehring, 1978). It was assumed that reading disability was a homogeneous entity and that a single underlying cause for the difficulty could be discovered. However, no satisfactory explanation was found. Wiener and Cromer (1967) and Appelbee (1971) expressed dissatisfaction with the simple models guiding reading disability research. They suggested that more complex models were needed in recognition of the diversity of reading disorders. Wiener and Cromer (1967) proposed a model which posited several types of reading disability, each associated with unique antecedents. Appelbee (1971) recommended a model for reading disability research which assumed that more than one syndrome of disability was possible and that reading disability could be caused by any of several relevant and independent patterns of factors. The complex research models also require complex statistical procedures.

Doehring (1978) agreed with the above suggestions and recommended a multiple-syndrome model in reading disability research. He argued that the single-syndrome research paradigm is not appropriate as it is not possible to operationally define reading disability as a unitary disorder. The simple models ignore the complexity of the reading process and rely on unidimensional measures of reading achievement. A narrow view of the reading process does not fit the complex problem of reading difficulty. A multiple-syndrome paradigm incorporates multiple measures of reading achievement. It assumes that there may be different subgroups of disabled readers, each associated with different patterns of reading skills and nonreading skills. Thus, the multiple-syndrome paradigm requires that research in reading disabilities examine both the reading skill characteristics and the nonreading characteristics of disabled readers.

There have been attempts to classify disabled readers into homogeneous subgroups on the basis of shared attributes. It is hoped that the identification of homogeneous subgroups will contribute to improvements in identification, remediation, and prediction of outcome of reading disabilities (Benton, 1978). The development of syndrome-specific treatment programs is seen to be an important outcome of classification research (Mattis, 1981).

Although the potential importance of identifying subgroups of disabled readers is widely recognized, research in this area has been particularly limited by the failure to adequately evaluate classification systems. Weaknesses are associated with the three classification approaches currently in use: rational definitions, clinical inferential and statistical. Thus, it is important to evaluate the coverage, internal validity and external validity of the subgroups formed (Morris, Blashfield & Satz, 1981; Satz & Morris, 1981). External validity is extremely important and requires that the subgroups be shown to differ on variables external to the variables used to form the subgroups.

Most attempts to classify disabled readers in subgroups have involved consideration of disabled readers from only one perspective, either reading characteristics or nonreading characteristics such as psychological and neuropsychological test performance. The research appears to confirm the heterogeneity of reading disorders and provides some indication of subgroups of disabled readers that may be identified. However, the classification studies which consider nonreading characteristics have ignored the complexity of the reading process and variations in reading behaviour among disabled readers. Most subgroups formed on the basis of nonreading characteristics have not been evaluated against external reading criteria. Similarly, few subgroups formed on the basis of reading and/or spelling characteristics have been evaluated against nonreading data to determine the distinctiveness of the nonreading characteristics of the subgroups.

Such research has failed to adequately interface differences in nonreading test performance with differences in reading behaviour. A classification system based upon neuropsychological and psychological test performance may have greater relevance to questions of etiology, identification, prevention, prognosis and remediation of reading disabilities if children in the different classifications can also be differentiated on the basis of reading characteristics. Conversely, if disabled readers classified into subgroups on the basis of differences in their reading and/or spelling behaviour differ in systematic ways on nonreading measures, then the classification schema will have greater relevance to the above questions.

A few recent studies have adopted a multiple-syndrome paradigm and considered both reading and/or spelling and nonreading characteristics of subgroups of disabled readers (e.g., Aaron, 1978; Doehring, Trites, Patel & Fiedorowicz, 1981; Lyon & Watson, 1981). However, in general, classification research to date has been limited by the classification approaches used, the selection of subjects for study, the selection of reading and nonreading measures, and particularly in the failure to adequately evaluate the coverage, internal validity and external validity of the classification solutions.

Within a multiple-syndrome paradigm, it is assumed that subgroups of disabled readers are characterized by different patterns of reading and nonreading characteristics. The interface between reading and nonreading characteristics among subgroups of disabled readers has important implications for our understanding of reading disabilities and was the central problem of interest in the present study.

Attempts were made to overcome limitations of previous research. Problems associated with subject selection in previous studies included the predominant use of clinic samples, the wide age range of samples and the failure to consider sex differences. For the present study, subjects were within a narrow age range (nine and ten years), thus controlling for the effects of varying chronological ages and developmental levels. The subjects were drawn from a nonclinic school population and included both boys and girls who were experiencing difficulty in reading.

The multiple-syndrome paradigm recommended for reading disability research was adopted in recognition of the complexity of the reading process and of disabled readers. This paradigm required comprehensive assessments of reading and nonreading characteristics. A major innovation of the present study was the reading assessment which considered strategies used in functional reading as well as standardized tests of word identification, word attack and passage comprehension. A wide range of nonreading characteristics was also assessed to prevent bias towards any one area of functioning.

Statistical classification procedures were selected as the most appropriate approach to classification with complex data. However, in view of weaknesses associated with current statistical classification procedures, two different methods were used and the coverage, internal validity and external validity of the classification solutions were evaluated.

One purpose of the present study was to determine if internally valid subgroups of disabled readers could be identified on the basis of reading characteristics using statistical classification procedures. A second purpose was to determine if internally valid subgoups of disabled readers could be identified on the basis of nonreading characteristics using statistical classification procedures. The primary purpose of the present study was to then examine the interface between reading and nonreading characteristics of the various subgroups formed. The external validity of the subgroups was thus extremely important. The nonreading characteristics of subgroups formed on the basis of reading characteristics and the reading characteristics of subgroups formed on the basis of nonreading characteristics were examined. In addition, the subjects in the subgroups formed on the basis of the two types of data were compared to determine if the same subjects were grouped together by analyses of the different types of data.

The determination of the nature of the interface between reading and nonreading characteristics of subgroups of disabled readers was considered to be important for understanding reading disabilities among public school children. If systematic relationships could be identified, identification and remediation procedures could be developed to respond to the distinctive patterns of reading and nonreading characteristics of the subgroups. If the patterns of relationships were complex, or weak, caution would be required in assuming simple relationships among these variables. The characteristics of interest for classification may differ with varying purposes for forming subgroups of disabled readers (e.g., for remedial teaching or for research).

II. Reading Disabilities from the Perspective of Nonreading Characteristics

Reading disabilities have been studied extensively from the perspective of nonreading characteristics. The focus has been upon identifying underlying processes thought to be associated with reading difficulties. Such processes are the concern of the disciplines of psychology and neuropsychology, which is the study of brain-behaviour relations (Reitan & Davison, 1974). Prior to the 1970's, most research followed a single-syndrome paradigm. A brief overview of this research will be presented. Interest in multiple-syndrome research has increased since the 1970's and this research will be reviewed in greater depth.

The research to be reviewed varies in sample selection criteria and may not always be concerned exclusively with disabled readers who are the focus of the present study. Some studies do not clearly define the nature of the learning disabilities of the subjects studied. Other studies vary in the exclusionary criteria used, in the severity of the reading difficulty, in the aspect of reading assessed, and in the method of assessment. There is thus little comparability of subjects across studies and generalizability is limited.

A. A Selective Review of Single-syndrome Reading Disability Research

Prior to the 1970's, reading disability research tended to follow a single-syndrome paradigm in which disabled readers were compared with normal readers on nonreading abilities and statistically significant differences were interpreted as evidence of underlying causes of reading disability (Doehring et al., 1981). Four of the most popular single factor explanations of reading disability based upon the single-syndrome paradigm are considered in the following review: visual processing, intersensory integration, sequential processing and memory, and linguistic processing. The literature relevant to each of these explanations is vast. Thus, the following review is limited to general conclusions and summaries of the research.

Visual Processes

Analysis of the reading process indicates that visual processing is involved in the early essential skill of differentiating and identifying letter shapes (Vernon, 1979). However, research comparing good and poor readers on visual processing tasks has yielded inconsistent findings across the various tasks requiring visual processing. Tasks involving visual analysis of complex arrays, discrimination of complex strings of verbal and nonverbal stimuli including rotated stimuli, and right-left discrimination have been performed poorly by disabled readers compared to good readers (Doehring, 1968; Lovell, Gray & Oliver, 1964; Taylor, Satz & Friel, 1978). In contrast, studies have reported no differences between good and poor readers on visual-motor, and spatial orientation tasks such as Block Design and visual matching of geometric forms (Levine & Fuller, 1972; Rugel, 1974; Symmes & Rapoport, 1972; Vellutino, Smith, Stager & Kaman, 1975).

Much of the inconsistency in the research may be attributed to the problem of sample heterogeneity. In addition, the construct validity of the tasks has not been clearly demonstrated. For example, controversy surrounds the degree to which the reader group differences on some visual perceptual tasks may be influenced by the sequential and/or verbal nature of the stimuli or of the response (Vellutino, 1979).

Intersensory Integration

In reading, visual patterns must be integrated with auditory temporal speech patterns. Thus, visual processing, auditory processing and the integration of information across the auditory and visual modalities appear to be involved in reading. Deficient performance on crossmodal, or intersensory, integration tasks requiring the matching of auditory sequential patterns to visual spatial patterns has been found among some disabled readers (e.g., Beery, 1967; Birch & Belmont, 1965). Auditory-visual tasks involving verbal stimuli (e.g., matching auditory and visual syllables, naming pictures) have yielded consistent differences between good and poor readers (e.g., Doehring, 1968; Levine & Fuller, 1972).

The explanation for poor performance by disabled readers on such tasks, however, is not clear. The construct validity of intersensory integration tasks is questionable. The tasks tend to involve dimensions which may contribute to the poor performance of disabled readers, such as sequential processing, short term memory, auditory processing, visual processing, attention and verbal processing (Benton, 1975; Vellutino, 1978). Intrasensory or within modality differences have frequently been ignored (Zurif & Carson, 1970).

Sequential Processing and Memory

To read, children not only need to match visual spatial and auditory temporal patterns, but they need to learn that the order of letters in printed words corresponds to the order of sounds in spoken words (Vernon, 1979). Thus, difficulties in perceiving and/or retaining the order of auditory and visual stimuli could result in reading difficulty.

One of the most consistent and reliable findings in reading disability research is the significantly poor performance by disabled readers in contrast to good readers on tasks requiring the recall of sequences of verbal stimuli in both the auditory and visual modalities (e.g., Ritchie &

Aten, 1976; Shankweiler, Liberman, Mark, Fowler & Fischer, 1979; Symmes & Rapoport, 1972). The verbal and sequential nature of the stimuli appear to be important in differentiating between good and poor readers. Verbal and sequential stimuli have yielded consistent differences between these groups. In contrast, nonverbal and nonsequential stimuli have not yielded consistent differences (e.g., Blank, 1968; Richardson et al., 1980).

It is difficult to sort out the critical aspects of sequential processing and memory tasks differentiating good and poor readers. Thus, the poor performance by disabled readers has been attributed to a sequential processing deficit or temporal order perception deficit (Bakker, 1972), to a general deficit in short term memory (Corkin, 1974), and to a verbal encoding or phonological encoding deficit (Jorm, 1979; Vellutino, 1979). Controversy thus surrounds the theoretical interpretation of serial memory deficits among disabled readers and the critical dimensions influencing poor performance by disabled readers remain the subject of debate.

Linguistic Processes

Reading is a language process and difficulties in three levels of linguistic processing are thought to be related to difficulties in reading. At the level of phonology, which involves the sound system of a language, evidence suggests that phonemic awareness measured by segmentation and synthesis tasks may be an important correlate of reading disability (e.g., Calfee, Lindamood & Lindamood, 1973; Golinkoff, 1978; Liberman, 1973). The difficulty in rapid naming found consistently among disabled readers in contrast to good readers (Denckla & Rudel, 1976; Spring, 1976; Wiig & Semel, 1976), and differences between good and poor readers in the recall of phonetically similar and dissimilar letter strings (Shankweiler et al., 1979) have also been put forth as evidence of phonological difficulties among disabled readers.

Syntax is the body of rules which governs the way words are arranged in sentences (Vogel, 1974). Studies of syntactic processing have found that, compared with good readers, disabled readers have difficulty applying morphological knowledge (e.g., Fletcher, Satz & Scholes, 1981; Vogel, 1974; Wiig, Semel & Crouse, 1973), in repeating sentences of increasing grammatical complexity (e.g., Denckla, 1977; Vogel, 1975; Weinstein & Rabinovitch, 1971), and in formulating sentences incorporating stimulus words (e.g., Doehring, 1968; Wiig & Semel, 1975).

Semantic processing involves the meaning of words and of sentences. Studies have reported inconsistent results in comparing disabled readers with good readers on measures of receptive vocabulary (Satz et al., 1974; Vogel, 1974), Vocabulary and Similarities subtests of the *Wechsler Intelligence Scale for Children (WISC)* (Wechsler, 1949) (Doehring, 1968; Lovell et al., 1964; Lovell, Shapton &

Warren, 1964; Rugel, 1974), and tests of verbal fluency (Fletcher et al., 1981; Taylor et al., 1979; Wiig & Semel, 1975).

Close examination of specific linguistic functions leads to the tentative conclusion that the data suggest, at best, a relationship between the three levels of language functioning and reading difficulty. The construct validity of tasks used to assess phonological, syntactic and semantic processes may be questioned. For example, rapid-naming may involve semantic word retrieval as well as phonological processes (Vellutino, 1978). Sentence repetition is thought to be influenced by sequential memory and receptive language factors, as well as syntactical comprehension (Vogel, 1975). Tests of verbal fluency require rapid production of items in a specified semantic category and may be influenced by speed of speech motor encoding as well as semantic production processes.

IQ and socioeconomic factors may influence performance on language measures and were not adequately controlled in many studies (Satz & Fletcher, 1980). Sample selection criteria varied widely across studies of linguistic processes and may have contributed to inconsistent findings. For example, Wiig and Semel (1975) assessed 34 "learning disabled" children who were academically retarded in two or more subjects, but not necessarily in reading. Vogel (1974) defined reading disability in terms of performance on a test of silent reading comprehension whereas Fletcher et al.

(1981) used a test of word recognition.

Summary

The selective review of single-syndrome research and the popular single factor explanations of reading disability revealed the inconsistency of the research findings. No single factor has been shown to consistently and reliably account for reading difficulty in all children. The lack of consistency in the research is likely influenced by the lack of comparability of the studies. Subject selection criteria varied across the studies reviewed in terms of age, sex, IQ, the severity of the reading deficit, the aspect of reading assessed and the source of the subjects (e.g., school population, clinic referrals).

Tasks used to assess various processes differed widely and the construct validity of tasks was a problem in all areas reviewed. Performance on similar tasks has been interpreted as reflecting a variety of processes. Considerable overlap was observed. Relationships among the various tasks tended to be ignored in studies adopting the single-syndrome paradigm which typically compared groups of good and poor readers on one or two measures.

Controversies regarding the most important correlates of reading disability may be resolved and more parsimonious explanations of reading disabilities may be forthcoming if comprehensive studies of disabled readers successfully identify homogeneous subgroups. The preceding review pointed to many processes which may be implicated in some instances of reading difficulty. The relationships among these processes and their relationship to reading achievement may be revealed in multiple-syndrome research studies which assess a wide range of processes among large groups of disabled readers and seek to identify subgroups of disabled readers who share common attributes. Multiple-syndrome research methodology will be described in the next section, followed by a review of relevant multiple-syndrome research studies.

B. Multiple-syndrome Reading Disability Research Methodology

In the 1970's, researchers showed a growing interest in multiple-syndrome reading disability research which assumes that there are several types of reading disability, each associated with different patterns of reading and nonreading characteristics (Doehring et al., 1981). The majority of studies adopting a multiple-syndrome paradigm have attempted to identify subgroups on the basis of nonreading performance, particularly on the basis of psychological and neuropsychological characteristics. Prior to the review of these attempts to identify subgroups of disabled readers, the research methodology of the studies is described. Systems for classifying disabled readers in homogeneous subgroups follow three general approaches: 1) rational definitions; 2) clinical inferential; and 3) statistical.

Rational Definition Approach

The rational definition approach, as described by Torgesen (1982), involves defining reading disabled subgroups on the basis of differences observed among disabled readers, such as differences in performance on memory tasks (e.g., Torgesen, 1982). The subgroups thus identified may be compared on other variables of interest in order to fully determine important differences among them.

Torgesen (1982) suggested several advantages of rationally defined subgroups: 1) clinical utility of findings; 2) clear definitions of samples to promote replication and extension of findings; 3) greater power to investigate subtle processing deficiencies; and, 4) the possibility of investigating the relationship between failure in school and failure on the criterion task and of developing relevant remedial programs.

One disadvantage of the rational definition approach is the subjective basis for defining the subgroups. The defining criteria will vary as they are influenced by the researcher's interests and a priori assumptions about reading disablities. The original basis of the definitions may not, in fact, be the critical factor separating the subgroups. Another important consideration is the relevance of the defining characteristics among disabled readers. How many disabled readers are affected by the defining criteria?

Clinical Inferential Approach

The clinical inferential approach to classification involves visual inspection of data. Subgroups are identified on the basis of subjective appraisal of scores. Such approaches have advantages in that multidimensional data and clinical relevance are considered. Disadvantages include the influence of the researcher's a priori assumptions regarding reading disabilities, difficulties in eyeballing complex data sets (Satz & Morris, 1980), and difficulties in simultaneously comparing the status on a large number of variables (Appelbee, 1971).

Statistical Approaches

Statistical methods of classification represent an objective approach in which classifications are generated through the search for the structure of complex multidimensional data sets (Satz & Morris, 1980). Recognition of the importance of a multidimensional approach to the study of reading disabilities has stimulated the demand for statistical procedures which can handle complex data sets and overcome some of the problems associated with clinical inferential approaches. There is little agreement as to the best approach to statistical classification. Cluster analytic techniques and the Q-technique of factor analysis have been used in learning disability and reading disability research.

Empirical methods for developing classification typologies aim to organize individuals according to similarities on specified variables (Overall & Klett, 1972). Profiles may be described in terms of level, dispersion and shape (Nunnally, 1967). Indices of profile similarity include distance functions and vector products.

In cluster analysis, a search procedure identifies an initial cluster nucleus based on the two most similar profiles using either distance function or vector product matrices. Similar individuals are then added to the nuclear cluster and other clusters are formed.

In the Q-technique of factor analysis, vector product matrices are used. The factors are "pure types" or "ideal types" and the subjects are then classified on the basis of their similarity to the ideal types. Factor loadings are indices of the relationship of the subjects to the ideal types (Overall & Klett, 1972).

Both statistical procedures have advantages and disadvantages. Overall and Klett (1972) favored Q factor analysis over cluster analysis for two reasons. First, Q factor analysis defines each cluster by considering relationships among a large number of individuals simultaneously whereas cluster analysis identifies the initial cluster nucleus on the basis of only two profiles which may be similar by chance. Thus, the results of Q factor analysis are more consistent and reproducible than the results of cluster analysis. Secondly, the ideal types defined by Q factor analysis are more distinct from one another than the clusters derived from cluster analysis.

Nunnally (1967) pointed out that Q factor analysis has the disadvantage of considering only the similarity of the shape of profiles. Level and dispersion are considered to be irrelevant and are equated in Q factor analysis. Other disadvantages include problems in handling subjects who have high loadings on more than one factor, and problems in meeting the assumption of linearity (Satz & Morris, 1980).

Cluster analysis includes a wide range of techniques for discovering groups of persons who are similar. Advantages include sensitivity to the elevation of profiles, flexibility in handling tests which are correlated, and the number of clusters is not limited by the number of measures (Satz & Morris, 1980). Disadvantages include deriving the initial nucleus on the basis of only two profiles which may be similar by chance (Overall & Klett, 1972), the methods will identify clusters in random data (Satz & Morris, 1980), and the various cluster analysis techniques yield varying results (Doehring, Hoshko & Bryans, 1979; Satz & Morris, 1980).

Evaluation of Classification Solutions

The rational definition, clinical inferential and statistical approaches to classification have weakenesses and thus classification solutions must be carefully evaluated. Satz and Morris (1981) and Morris, Blashfield and

Satz (1981) outlined several issues relevant to the evaluation of classification systems. Coverage, internal validity and external validity are of particular importance.

Coverage refers to the "extent to which the classification schema incorporates those subjects it is intended to represent" (Satz & Morris, 1980, p.12). Internal validity involves the evaluation of the adequacy and stability of the classification solution. The evaluation of the homogeneity of the subjects within the subgroups and cross-validation of the system using various samples are relevant to internal validity. Satz and Morris (1980) described the "ultimate test" of subgroup validation as external validation in which subgroups are tested on criterion variables external to the variables used in the classification.

C. Review of Reading Disability Subgroups Based on Nonreading Performance Variables

The majority of studies attempting to classify disabled readers in homogeneous subgroups have considered performance on nonreading measures. Attempts to group together disabled readers on the basis of similar nonreading characteristics are reviewed in this section.

Rationally Defined Subgroups

WISC Profile Subgroups. Disabled readers have been classified in subgroups on the basis of Verbal-Performance

IQ splits on the *Wechsler Intelligence Scale for Children (WISC)* (Wechsler, 1949). A low Verbal-high Performance IQ profile indicative of a verbal decrement has been identified among a large proportion of disabled readers (Belmont & Birch, 1966; Nelson & Warrington, 1974; Warrington, 1967). A smaller proportion appear to be characterized by a performance decrement, possibly indicative of poor spatial ability (Warrington, 1967). However, the latter pattern is less likely to be associated with severe reading deficit (e.g., Rie & Rie, 1979).

Subgroups of learning disabled children defined on the basis of Verbal IQ-Performance IQ (VIQ-PIQ) patterns have been found to differ in performance on nonreading variables. A low VIQ-high PIQ pattern was found to be associated with deficits on language measures whereas a high VIQ-low PIQ pattern was found in conjunction with manifestations of sequencing or visual perceptual difficulty (Kinsbourne & Warrington, 1963; Rourke, Young & Flewelling, 1971).

Short Term Memory Subgroups. Learning disabled children have been divided into subgroups on the basis of the presence or absence of a substantial auditory short term memory deficit on the Digit Span test of the *WISC* (Torgesen, 1982). The subgroups differed in performance on several other short term memory tasks but not in visual nonverbal sequential memory, sorting recall, recognition memory or memory for content. The short term memory deficit subgroup also had greater difficulty in following directions, learning to spell new words and sound blending.

Critique of Rationally Defined Subgroups

A key difficulty in the rational definition approach is determining how many disabled readers are affected by the defining criteria. Short term memory subgroups have low coverage. For example, Torgesen's (1982) short term memory problem subgroup may represent 10% to 15% of learning disabled children.

The coverage of classification systems based on VIQ-PIQ discrepancies depends upon the magnitude of the discrepancy. It is important to determine how relevant the criterion difference is among disabled readers. For example, a low VIQ-high PIQ split of 20 or more points was found among a large proportion of disabled readers whereas a high VIQ-low PIQ pattern was rare (Nelson & Warrington, 1965). Thus, comparisons of subgroups selected on the basis of a 20 point split will be of little relevance because members of the high VIQ-low PIQ subgroup will seldom be encountered in clinical practice. The VIQ-PIQ pattern may be of relevance in identifying subgroups if the critical magnitude and direction of the pattern can be determined. The important classification may be based on a low VIQ-high PIQ pattern versus a balanced VIQ-PIQ pattern (e.g., Cohen & Netley, 1978).

The defining criteria will vary in terms of a researcher's interests and a priori assumptions about reading disabilities. Thus, it is important to evaluate the internal validity of the subgroups to determine the critical differences among them. The original basis of the definitions may not in fact be the critical factor separating the subgroups. Torgesen (1982) found significant differences among short term memory subgroups of disabled readers on several memory tasks thus indicating internal validity.

Internal validity may also be evaluated by comparing the stability of the subgroups across various samples of children with learning disabilities. Although a low VIQ-high PIQ pattern was found to be more prevalent than a high VIQ-low PIQ pattern among different samples of children with learning disabilities, the actual percentages differed widely across the studies by Warrington (1967) and Nelson and Warrington (1974).

Clinical Inferential Subgroups

Etiology. Differences observed among disabled readers have been the basis for classification systems which infer different etiological bases for the subgroups observed. Rabinovitch (1968) classified reading disability as "primary" or "secondary". Primary reading disability was attributed to an assumed basic disturbed pattern of neurologic organization, in the absence of a history of brain damage and positive signs on neurological examination. Secondary reading disability was assumed to be caused by exogeneous factors such as brain damage, emotional disturbance or environmental deprivation.

Bannatyne (1971) also grouped together reading disabled children to form more homogeneous subgroups for which he assumed different etiologies. The four classifications were genetic dyslexia, minimal neurological dysfunction dyslexia, social cultural educational deprivation dyslexia and emotional motivational dyslexia.

Neuropsychological Variables. Three studies identified subgroups of disabled readers by appraising neuropsychological test data. Mattis, French and Rapin (1975) formed three distinctive and independent patterns of deficits which included 90% of a sample of 82 disabled readers: 1) language disorder (39%); 2) articulation and graphomotor dyscoordination disorder (37%); and, 3) visuo-spatial perceptual disorder (16%).

Denckla (1977) used Mattis et al.'s (1975) neuropsychological test performance criteria to classify children with reading/spelling difficulty into the three syndromes. Again, the language disorder was largest (65%), followed by the articulatory graphomotor syndrome (12%). However, an independent visuo-spatial perceptual syndrome was absent, and a fourth verbal memorization syndrome (10%) was identified. Denckla subdivided the language disorder into pure anomia (4%), anomia plus a repetition disorder (27%), a dysphonemic sequencing disorder (13%) and mixed language difficulties (17%).

In a cross-validation study, Mattis (1978) reported that 77% of 163 culturally and economically disadvantaged disabled readers were classified in the three syndromes identified by Mattis et al. (1975): language disorder (63%); articulatory graphomotor disorder (10%); and visuo-spatial perceptual disorder (5%). Ten percent presented with Denckla's (1977) dysphonemic sequencing syndrome. The syndromes were not independent.

The three studies demonstrated that subgroups of disabled readers could be identified on the basis of patterns of performance on nonreading tasks. Three processes appeared to be critical to reading: language development, motor speech blending fluency and visual-spatial perception. It was suggested that disruption in any of these processes could result in atypical reading, although visual perceptual problems were relatively rare.

Critique of Clinical Inferential Classification Systems

The etiological classification systems have not been objectively verified. The subjectivity of the inferences raises the question of reliability. The utility of etiological classification systems is questionable.

The neuropsychological syndromes must be considered cautiously until they are validated against external reading criteria. Mattis et al. (1975) provided clinical impressions of the reading errors associated with the three neuropsychological syndromes. For example, the language disorder sydrome was characterized by neologisms (errors that were nonsense words) and faulty letter-sound associations. However, they cautioned against the use of patterns of reading errors in classifying disabled readers because similar errors could result from different processing deficiencies. However, this claim has not been substantiated. The relationship between reading errors, or reading strategies, and patterns of performance on neuropsychological measures has not been adequately investigated.

The series of three studies of neuropsychological syndromes represents an important attempt to cross-validate the classification system. Coverage was high in each study. However, internal validity reflected in the reliability of the syndrome classifications across different samples was not convincing. The proportions of children in the subgroups varied across studies and the independence of the syndromes was not maintained. The wide age range of the children may have contributed to differences among subgroups. For example, Denckla's (1977) verbal memorization syndrome was observed among older children in her sample. Unfortunately, the mean age of each subgroup was not reported in the three studies. The possible contribution of sex differences to subgroup differences was not considered. The validation attempts were undertaken with special populations, i.e. clinic referrals, "minimally brain damaged" and disadvantaged. Validation with other samples of disabled readers is indicated.

Statistically Derived Subgroups

Q Factor Analysis. Petrauskas and Rourke (1979) used Q factor analysis to identify subtypes of disabled readers based on differential patterns of performance on a battery of neuropsychological measures. The reliability of the subgroups was determined by dividing the subjects into two subsamples, and analyzing each separately. Five subgroups were identified in each subsample. Approximately 50% of the total sample was classified in three subgroups which were reliable across the subsamples: 1) language disturbance subgroup (25%); 2) linguistic sequencing deficit (16%): and, 3) conceptual flexibility deficit (8%).

Fisk and Rourke (1979) applied Q factor analysis to neuropsychological test scores of large samples of children experiencing difficulty in all academic areas. The analyses were computed separately for three age levels (9-10, 11-12, and 13-14 years). Three subgroups were reliable across the three age levels. However, coverage was low: 39% were classified in the three subgroups at age 9-10; 65% at age 11-12; and, 59% at age 13-14. Subtypes A and C had similar deficits in tactile perception. However, Subtype C was not observed among 9- and 10-year-olds. Subtype B was characterized by deficiencies in phonemic hearing and auditory-verbal memory.

Cluster Analysis. In an early attempt to use statistical methods to identify subgroups of reading problems, Naidoo (1972) used a single linkage cluster analysis method in a study of 92 reading disabled boys. This technique was applied to a wide variety of nonreading measures. Naidoo's analysis did not support the existence of clearly defined subgroups of disabled readers. Four subgroups were created with 70% of 92 subjects classified in the subgroups.

Satz and Morris (1980) applied cluster analytic techniques to the nonreading test performance of 89 boys experiencing academic difficulties. Four different cluster analytic techniques applied to two language tests and two perceptual tests each yielded five distinct subgroups: global language impairment (30%), naming impairment (16%), mixed language and perceptual impairment (11%), visual perceptual motor impairment (26%), and no impairment (13%). Coverage was high with 96% of the children classified in the subgroups. External validity was considered and although there were no significant differences among the subgroups in reading, spelling and arithmetic achievement, the subgroups differed in neurological status, socioeconomic status and parental reading levels.

The reliability of the subgroup classifications was investigated by carrying out data manipulations. A split-half design which applied the cluster analysis to two random subsamples of the children replicated the original subgroups. The addition of a language and a perceptual variable resulted in fewer than 12% of the subjects changing from the original subgroups. Satz and Morris (1980) noted that these two variables were highly redundant with the four original clustering variables and thus did not decrease the stability of the original subgroups. The addition of achieving children did not disturb the original subgroups of learning disabled children.

Critique of Statistically Derived Subgroups

The statistical classification procedures represent a multidimensional approach to reading disability which recognizes the heterogeneity of reading disorders. However, all of the studies presented may be criticized for adopting a unidimensional view of the reading process. Each study defined disabled readers on the basis of a limited assessment of word recognition level and variations in the reading characteristics of disabled readers were not considered. Only Satz and Morris (1980) attempted to validate the subgroups against reading criteria external to the classification variables. In view of the disadvantages of statistical classification techniques outlined earlier, it is extremely important that the subgroups be validated against external criteria.

Naidoo's (1972) work has weaknesses related to methodological flaws in the early period of the development of cluster analytic techniques (Satz & Morris, 1980).

Doehring, Hoshko and Bryans (1979) suggested that other methods of cluster analysis now available produce more interpretable classifications than those produced by the single linkage procedure.

Satz and Morris (1980) presented a comprehensive application of current cluster analytic techniques to the identification of subgroups of reading disabled boys drawn from a school population. Coverage was high. Internal validity was demonstrated by several data manipulations. However, the subgroup classifications were based on a limited assessment of the processing abilities of the disabled readers. Only four tests were used to derive the subgroups. In view of the multitude of correlates of reading disability, it is doubtful that an assessment limited to four tests will adequately represent the distribution of abilities and deficits in the reading disabled population. The selection of a minimum number of processes to be assessed is highly vulnerable to the biases of the researcher. The external validity of the subgroups was not supported when evaluated against reading achievement measured by a word recognition task.

The subgroups formed on the basis of Q factor analyses of neuropsychological tests appear to be of limited usefulness. Petrauskas and Rourke (1979) introduced important controls including a split-half reliability check, a normal control group, and a limited age span. The generalizability of findings was limited by the use of clinic referrals and the exclusion of females from the sample. The split-half reliability technique yielded three of five reliable subgroups. However, coverage was low and fifty percent of the disabled readers did not fit in the reliable subgroups. Normal readers did not emerge as a separate subgroup which may limit the validity of the classifications. Most importantly, the subgroups were not validated against external reading criteria.

Fisk and Rourke (1979) provided an interesting cross-sectional evaluation of Q factor analysis subgroups at three age levels. Generalizability was limited by the sample of boys and girls referred to a clinic for evaluation of "suspected cerebral dysfunction". Reliability estimated across age levels was demonstrated for three of six subgroups. Subtype C did not include 9- and 10-year-olds and was very similar to Subtype A making the distinctiveness of the subgroups and their internal validity questionable. Coverage was low for the three subgroups which limits the applicability of the findings. The external validity of the subgroups was not addressed.

Summary

The research presented confirms the heterogeneity of disabled readers in performance on nonreading variables. However, none of the proposed classifications is likely to be adopted for wide use in the field of reading disabilities. All of the systems require cross-validation with well-defined samples of disabled readers and validation against external reading criteria.

Of the three classification techniques presented, statistical classification procedures appear to have the greatest potential for identifying homogeneous subgroups on the basis of multidimensional data. Clinical inferential techniques are biased by a priori assumptions about reading disability and by difficulties in the visual inspection of complex data sets. Rationally defined subgroups have potential in reading disability research. However, as yet, the basis for rational definitions is largely clinical inferential and affected by a priori assumptions.

Statistical classification procedures also have disadvantages. As with other procedures, the statistical techniques are influenced by the subjects and the measures selected. Thus, cross-validation and reliability data are necessary. Issues of coverage, internal validity and external validity must be considered. The inclusion of a wide range of processes is likely to yield the most comprehensive classification system. Studies which were limited in the number of measures identified subgroups which were not impaired on the dimensions assessed (e.g., Satz & Morris, 1980)

Despite the methodological problems and wide variations in the research reported, the results indicate that future research may successfully identify homogeneous subgroups of disabled readers. A large subgroup with linguistic processing deficiencies was consistently reported (Denckla, 1977; Mattis, 1978; Mattis et al., 1975; Petrauskas & Rourke, 1979; Satz & Morris, 1980). A small subgroup with visual perceptual difficulties was identified less consistently (Denckla, 1977; Mattis, 1978; Mattis et al., 1976; Satz & Morris, 1980). Speed of processing, reasoning, sensory skills and sequential processing also contributed to the identification of subgroups but variations in measures prevent the clear observation of overlap across studies.

The most critical limitation of all of the classifications presented in this chapter is the failure to validate the subgroups against external reading criteria. Reading and spelling characteristics which may be important for the identification of subgroups of disabled readers are reviewed in the next chapter in which disabled readers are considered from the perspective of their reading and spelling behaviour.

III. Reading Disabilities from the Perspective of Reading and Spelling Characteristics

The complexity of nonreading performance characteristics of disabled readers was evident in Chapter II. Reading disability research must also recognize the complexity of the actual reading behaviour of disabled readers, and the potential importance of spelling characteristics in advancing understanding of the processing of written language. In the present chapter, models of the reading and spelling processes are outlined briefly to highlight their complexity. Characteristics of the reading and spelling behaviour of disabled readers are then discussed. Finally, attempts to form subgroups of disabled readers on the basis of reading and/or spelling characteristics are reviewed.

A. The Reading Process

The reading process consists of two main components: word recognition and comprehension (Levin, 1970; Smith, 1971). Word recognition involves the identification of words, usually reflected in pronouncing words in isolation or in context. Comprehension involves understanding the meaning of individual words, phrases, sentences or discourse. Although it is generally agreed that comprehension is the goal of reading, there is little agreement as to how meaning is derived from written language or what aspect of comprehension should be considered.

In reading, several types of information are available. Individual words may be defined as a complex of features which include graphic features (type of print, word shape, position of letters, letter shapes), phonological and orthographic features (spelling-sound correspondence), syntactic features (grammatical inflections such as tense markers), and semantic features (meaning) (Gibson & Levin, 1975). The properties of connected text include visual properties (rows of letters with spacing and punctuation), grammatical properties (regularly recurring sequences of words, phrases, clauses and paragraphs), and semantic properties (word attributes, propositions and themes) (Doehring & Aulls, 1979).

The reader brings certain skills to the reading situation, such as visual skills to discriminate letters and to scan from left to right, orthographic knowledge of associations between printed graphemes and phonemes, and three levels of language skill, namely, phonological, syntactic and semantic (Doehring & Aulls, 1979). The phonological level involves information about the acoustic, articulatory and phonemic properties of words and includes such skills as auditory discrimination, phonemic segmentation, and sound blending. Syntactic knowledge refers to knowledge about the body of rules which governs the way words are arranged in sentences and morphological rules governing inflections (Vogel, 1974). The semantic level is the level of meaning.

Models of the reading process are of three main types: Top-down, Bottom-up and Interactive. The models differ in the importance given to the various levels of information available in printed words and text, and to the reader's active participation in the reading process. The models also differ in the reader variables thought to be important in successful reading and thus implicate different processes in reading difficulty.

Top-down models emphasize the reader's active role in generating and testing hypotheses regarding the meaning of the text (Rumelhart, 1977). For example, Smith (1971, 1973) and Goodman (1968, 1970) adopt a psycholinguistic view of the reading process. The reader is thought to interact with the text using strategies of sampling, predicting, confirming and correcting to construct meaning (Goodman & Gollasch, 1980). Comprehension is thought to precede word recognition with the reader predicting words and then sampling the graphic display to test hypotheses. The reader's use of syntactic and semantic cues in reading is emphasized; the importance of grapho-phonic cues is minimized.

Reading difficulty, considered from a top-down perspective, may be related to limited use of syntactic and semantic cues for generating hypotheses. Poor use of contextual redundancy would result in fewer, or incorrect, hypotheses and require greater processing of visual information for word recognition. As a result, reading would be slow and laborious.

Bottom-up models of the reading process attribute a more passive role to the reader and have been described as "text driven" (Carr, 1981). Gough (1972) proposed that reading involves serial letter by letter visual analysis. The letters are mapped onto systematic phonemes and then matched to a lexicon to obtain meaning. Syntactic and semantic processes are not thought to influence the decoding of words.

Laberge and Samuels (1974) proposed an information processing model of reading which posits several stages progressing in a bottom-up direction. The process begins with visual information which is transformed through four major processing stages: visual memory, phonological memory, episodic memory and semantic memory. At each level, the criteria of achievement are accuracy and automaticity. Contextual cues are not given a central role in word identification.

Bottom-up models posit several sources of reading difficulty, such as the discrimination of the distinctive features of individual letters, the sequential processing of letter clusters, the acquisition of sound-grapheme correspondence rules, and the semantic memory for phonological or graphic representations of words. Inefficiency in subskill areas may interfere with fluent reading by requiring attention and slowing the reading process.

Interactive models combine features of top-down and bottom-up models of the reading process. Top-down hypothesizing reduces bottom-up letter by letter or word by word analysis (Gibson & Levin, 1975). Interactive models of reading present the reader as a flexible problem-solver who may select different strategies in various reading situations. Text properties will influence the strategies chosen. Guessing on the basis of context may be efficient in reading highly structured familiar material whereas decoding individual words may be more efficient when the text is not highly structured. The reader may also choose to rely on letter level knowledge if the information in the syntactic knowledge source is limited. Reader variables, such as the level of development of cognitive and linguistic skills, may also affect the choice of strategies.

Stanovitch (1980) proposed that interactive models plus a compensatory mechanism may provide the best account of individual differences in reading. He assumed that a process at any level may be used to compensate for deficiencies at any other level. For example, a reader who has poor knowledge of spelling-sound correspondence rules may rely on contextual cues to provide additional information.

The models of the reading process highlight its complexity. The need to consider how a reader uses the various types of information available in reading is evident. Information about the processing of written language has also been obtained through studying the spelling process and its relationship to reading, which are discussed in the next section.

B. The Spelling Process and its Relationship to the Reading Process

Spelling and reading are processes of written language analogous to the speaking and listening processes of spoken language. Thus, reading and spelling have been viewed as reciprocal processes. The spelling strategies of individual children were thought to mirror their reading strategies (e.g., Boder, 1973). However, there is increasing acceptance of the view that reading and spelling are independent and asymmetrical processes (e.g., Barron, 1980; Bradley & Bryant, 1979; Frith, 1979; Gibson & Levin, 1975).

It is generally accepted that at least two strategies may be used in spelling: a sound, or phonological, strategy and a visual orthographic, or visual analogy strategy (e.g. Barron, 1980; Bradley & Bryant, 1979; Frith, 1980; Nelson, 1980). Frith (1980) developed a three stage theory of spelling which attributes a primary role to sound. First, the target word is analyzed into speech sounds or phonemes; second, the derived phonemes are converted into graphemes following sound-to-spelling correspondence rules or analogies; and third, the conventionally correct graphemes are selected from the alternative plausible graphemes which produce equivalent phonetic representations. Nelson (1980) proposed that a semantic-graphemic route accesses specific information about the spelling of a word which is directly associated with the meaning of the word and is important in selecting the conventional graphemic equivalents.

The phoneme-grapheme and visual or semantic-graphemic routes in spelling correspond loosely to two routes thought to be available in reading, namely, a phonological strategy which involves applying spelling to sound correspondence rules and a visual orthographic strategy which involves direct processing from print to meaning. Despite the apparent similarity of such strategies, evidence supports the independence of reading and spelling processes. Spelling is considered to be more difficult than reading (Bradley & Bryant, 1979; Frith, 1980; Nelson, 1980). Cerebral lesions can selectively impair reading or spelling indicating differentiation at the anatomical level (Nelson, 1980). Independence is also supported by the existence of poor spelling in association with well developed reading ability (Frith, 1980; Nelson & Warrington, 1974) and by children's ability to spell words they cannot read and to read words they cannot spell (Bradley & Bryant, 1979).

C. Characteristics of the Reading Behaviour of Disabled Readers

Early in the history of reading research, investigators recognized the complexity of the reading process and of individual differences in the reading behaviour of children who encountered difficulty in reading (e.g., Gates, 1922;

Monroe, 1932; Robinson, 1946). However, as with research concerned with the nonreading characteristics of disabled readers, the single-syndrome paradigm has dominated studies of reading characteristics. Good and poor readers have been compared on various measures with the goal of isolating reading characteristics which distinguish disabled readers from proficient readers. Word recognition in isolation and in context, comprehension, and oral reading strategies have been assessed. In this section, a selective review of the literature comparing good and poor readers on reading tasks is presented.

Several approaches to identifying the locus of reading difficulty among disabled readers in the intermediate grades have yielded information about the characteristics of their reading behaviour. Studies of word recognition and of oral reading of connected text will be reviewed.

Context-free Word Recognition

The identification of words presented in isolation appears to be a source of individual differences in reading ability. Evidence suggests that slow inaccurate decoding is characteristic of disabled readers in the intermediate grades (Guthrie & Tyler, 1978). The speed and accuracy of word-naming have been shown to be associated with paragraph reading fluency (e.g., Shankweiler & Liberman, 1972) and with comprehension (e.g., McCormick & Samuels, 1979).

Word recognition difficulty has been attributed to difficulty using the phonological route in reading. Supporting evidence includes slow inaccurate reading aloud of low frequency and nonsense words by disabled readers compared with good readers (e.g., Barron, 1980; Perfetti & Hogaboam, 1975) and poor matching of pseudowords on the basis of sound cues (Mackworth & Mackworth, 1974). However, context-free word identification limits the choice of reading strategies.

Word Recognition in Isolation versus Context

It is now generally accepted that contextual cues have a facilitative effect on word recognition. Context has been found to facilitate accuracy and speed of word recognition for both good and poor readers when the same words are presented in isolation and with contextual cues (e.g., Allington & Fleming, 1978; Allington & McGill-Franzen, 1980; Schvaneveldt, Ackerman & Semlear, 1977; West & Stanovitch, 1978).

Although disabled readers are able to make use of contextual cues, results are inconsistent in describing disabled readers and proficient readers as text-driven (i.e., grapho-phonic cue users), or concept-driven (i.e., contextual cue users). For example, Juel (1980) found that poor readers in grades two and three were concept-driven and good readers were text-driven. In contrast, Patberg, Dewitz and Samuels (1981) found that poor readers in grade two were text-driven but those in grade four were concept-driven whereas good readers were concept-driven at both grade levels. Studies were limited to assessing the use of contextual cues in single-word context and in sentence context. The stategies used by disabled readers in reading passages of connected text are examined next.

Oral Reading Analyses

Samples of oral reading of connected text provide information about the reader's use of contextual cues as well as graphic and phonemic cues to identify words and to derive meaning from written text. Although oral reading may not involve the same processes as silent reading, oral reading responses are easily obtained and have yielded significant clues about the nature of the reading process (Weber, 1968). Errors may be analyzed quantitatively (i.e., counting error types), or qualitatively (i.e., evaluating the cues used to produce an error and the effect of the error on the surrounding text). Reading speed may be analyzed to reflect the efficiency of using reading strategies.

Despite variations in the definition of oral reading error categories across studies, there are identifiable trends in the types of errors produced during the oral reading of passages. Substitution of another word (real or nonsense) for the target word is the most common error and reversals of letters and words are the least common errors across various levels of reading proficiency (Graham, 1980; Hood, 1975; Leslie, 1980).

Quantitative analyses of error types indicate that poor readers make more errors than good readers but they do not differ in the types of errors made (e.g., Graham, 1980). The quantitative analyses do not identify the strategies that a child is using in reading a passage, nor do they indicate the effect the errors have on the meaning of the passage. Weber (1968) emphasized the importance of taking into account various linguistic levels in analyzing oral reading errors, including the sound-letter, syntactic and semantic levels. Weber (1970) analyzed oral reading errors qualitatively. The use of graphic cues was determined by evaluating the graphic similarity of the error to the target word in the text. The use of syntactic or contextual cues was determined by evaluating grammatical acceptability, i.e., the appropriateness of the error to the grammatical context.

Goodman and Burke (1972) developed a qualitative analysis of oral reading errors to evaluate the use of graphic, phonic, syntactic and semantic cues and to determine the effect of errors on the meaning of the passage. Errors were referred to as "miscues" based on the belief that they are produced by the same process and in response to the same cues which produce expected responses.

Among beginning readers, qualitative analyses of oral reading errors have demonstrated that the majority of errors made by both good and poor readers are contextually appropriate; however, the errors of the good readers share greater graphic similarity with the text than those of poor readers (Biemiller, 1971; Weber, 1971). These findings were also confirmed when the difficulty level of passages was equated for grade one good and poor readers (Biemiller, 1979).

Although beginning poor readers make high use of contextual cues, they appear to be less sensitive than good readers to the effects of errors on the surrounding text. Weber (1970) found that good readers corrected 85% of their grammatically unacceptable responses; poor readers corrected only 42% of these errors. Greater self-correction by beginning good readers has also been reported by Clay (1968) and Cohen (1975).

There have been few qualitative analyses of oral reading errors of good and poor readers in the intermediate grades. The available studies are methodologically weak and lack comparability. Studies have reported that poor readers rely heavily on simple strategies, such as graphic and phonic cues and simple grammatic function cues, in contrast to reliance on more sophisticated syntactic and semantic cueing systems by proficient readers (e.g., Levy, 1977). Others failed to find differences in the strategies used by disabled and normal readers (e.g., Graham, 1980).

Such studies frequently fail to take into account differences in error rate which may contribute to strategy differences between good and poor readers. Among average readers, there is an increased reliance on the use of graphic and phonic cues and a decreased reliance on contextual cues as the level of difficulty of the reading material increases (Christensen, 1969; Pflaum, 1979; Williamson & Young, 1974). Disabled readers also show a decreased use of syntactic and semantic cues as the difficulty level of passages increases (Kibby, 1979).

Leslie (1980) equated the error rate in comparing the graphic and contextual appropriateness of oral reading errors of second grade average readers and poor readers in grades three to six. For both good and poor readers, the syntactic appropriateness of miscues decreased and errors changing the author's meaning increased as the error rate increased. At all levels of difficulty, the poor readers showed greater reliance on graphic information, although frequently unsuccessful in using it, and made a greater proportion of errors which changed the author's meaning.

Qualitative analyses of oral reading have thus yielded inconsistent findings regarding the use of graphic, phonic, syntactic and semantic cues by disabled readers compared with proficient readers. Studies of oral reading errors are limited by methodological problems which include: small sample size; failure to control age, IQ and the difficulty level of the passages; failure to provide reliability data; vague statistical treatment of data; and, differences across studies in the types of errors selected for qualitative analysis (e.g., all substitution errors vs. only meaningful substitution errors) and in the criteria for defining qualititative categories (e.g., graphic similarity based on the first letter alone or on all of the letters).

The possibility that there may be individual differences in the reading strategies of disabled readers warrants study. The preceding review points to the following important considerations in examining individual differences in the reading behaviour of disabled readers: word recognition and comprehension levels and the speed of reading should be compared; the degree of reading deficit, age and IQ of the disabled readers should be considered; the level of difficulty of the reading material must be controlled; repeated samples of oral reading behaviour are recommended; and the reliability of the qualitative analyses of errors must be demonstrated.

D. Characteristics of the Spelling Behaviour of Disabled Readers

The relationship between reading and spelling as written language processes led to interest in the spelling behaviour of disabled readers. The level of achievement in spelling tends to be low among disabled readers (e.g., Naidoo, 1972).

Differences in the quality of spelling errors of disabled readers and proficient readers have been examined. Phonetically accurate misspellings are thought to reflect the phonemic-graphemic route to spelling (Frith, 1980). Phonetically inaccurate misspellings are thought to reflect a visual strategy (Boder, 1973), or to reflect problems in using a phonological strategy (Frith, 1980).

Phonetically inaccurate misspellings have been reported among a large proportion of disabled readers (63% of 107 disabled readers) while phonetically accurate misspellings characterized a smaller number (9%) (Boder, 1973). Children who are underachieving in both reading and spelling make more phonetically inaccurate errors than children who have difficulty in spelling only, or than children who are achieving in both reading and spelling (Frith, 1979; Nelson & Warrington, 1974). Phonetically inaccurate misspelling thus appears to be associated with reading difficulty. However, individual differences within samples of disabled readers have been reported (e.g., Boder, 1973).

E. Review of Reading Disability Subgroups Based on Reading and/or Spelling Characteristics

Attempts to classify disabled readers into homogeneous subgroups based on shared reading and/or spelling characteristics using the rational definition and clinical inferential approaches are reviewed in this section. Statistical classification procedures have not yet been used in studies which focus only upon the reading and spelling characteristics of disabled readers.

Rationally Defined Subgroups

Comprehension and Word Recognition. Subgroups of disabled readers who differ in relative levels of functioning on tests of word recognition and comprehension have been found to differ in oral reading strategies (Kendall & Hood, 1979). When compared on passages equated for difficulty level, children with High Comprehension-Low Word Recognition (HiC-LoWR) used more contextual information, read more slowly and answered more questions correctly than children with Low Comprehension-High Word Recognition (LoC-HiWR). However, when compared on the same passage, which was more difficult for the HiC-LoWR children, the HiC-LoWR subgroup made less use of contextual information.

Reading Words in Isolation versus Context. Results are inconsistent regarding the existence of subgroups of disabled readers characterized by relative proficiency in reading the same words in isolation and in context. Allington (1978) observed two subgroups of disabled readers: one subgroup read more words correctly in isolation than in context; the other group read more words correctly in context than in isolation. The disabled readers appeared to be ineffective in using syntactic and semantic cues as only 27% of errors in context were syntactically and semantically acceptable. However, in a similar study with less severely disabled readers, all disabled readers read more words correctly in context than in isolation (Allington &

McGill-Franzen, 1980).

Critique of Rationally Defined Subgroups

The rational definition approaches to the identification of subgroups of disabled readers had methodological weaknesses. Sample sizes were small, statistical comparisons were limited and some conclusions were based on the visual inspection of data.

The importance of the various criteria defining the subgroups within the total reading disability population has not been established. Subgroups based on relative levels of comprehension and word recognition comprised only 24% of a sample of 160 disabled readers (Kendall & Hood, 1979).

The internal validity of subgroups based on the relative difficulty of reading words in isolation and in context was considered. However, Allington and McGill-Franzen (1980) were not able to cross-validate the subgroups of disabled readers identified by Allington (1978) in a sample of less severely disabled readers.

Kendall and Hood (1979) attempted to validate the subgroups by relating the defining criteria to external variables, specifically, to reading strategies used in the oral reading of connected text. However, larger samples and stronger statistical techniques are required to demonstrate the external validity of the subgroups.

Clinical Inferential Subgroups

Patterns of Reading Errors. The importance of observing differences in the reading characteristics of disabled readers has received support from neuropsychological studies of adult alexics who have acquired reading problems following brain damage. Benson (1977) described three subtypes of alexia, each associated with distinct clinical and anatomical characteristics. The individual variations in the reading of alexics appear to be dependent on the location of the underlying pathology in the central nervous system. Marshall and Newcombe (1973) proposed a taxonomy of oral reading errors of acquired alexics categorizing errors as visual, semantic or grapheme-phoneme impairment. Three subgroups of alexics were identified on the basis of differences in reading errors: visual dyslexia, deep dyslexia and surface dyslexia.

There have been few in-depth studies of patterns of reading errors among children with reading difficulties. Audio-phonic errors (e.g., confusion of vowel sounds, poor blending) have been found to be more frequent among children who are underachieving in reading and spelling only ("specifics") than among children who are underachieving in arithmetic as well as reading and spelling ("generals") (Ingram, Mason & Blackburn, 1970). Conversely, visuo-spatial errors (e.g., directional errors) were most frequent among the "generals". Thus, reading difficulty appeared to be associated with auditory processing in some children and with visual processing in other children.

Orton (1937) suggested that reversals of sequence and reversals of orientation were characteristic of disabled readers. However, Liberman, Shankweiler, Orlando, Harris and Berti (1971) found that reversals comprised a small proportion of errors on 60 words read individually by poor readers in grade two. Reversals of sequence comprised 10% of errors and reversals of orientation comprised 15% of errors. The most frequent errors were vowel errors (43%) and consonant errors (32%). There were large individual differences in making reversal errors. Only some poor readers reversed, with reversals of sequence ranging from 4% to 19% of the errors of individual children and reversals of orientation ranging from 3% to 32% of errors.

Patterns of Reading and Spelling Errors. Boder (1973) proposed a system for classifying disabled readers in subgroups based on patterns of errors. Three subgroups characterized by different patterns of errors on reading and spelling tasks were identified in a sample of 107 disabled readers: Dysphonetic (63%); Dyseidetic (9%); and Mixed (21%).

The Dysphonetic dyslexic appeared to have basic deficits in the auditory channel, read words globally as instantaneous visual gestalts, lacked word analysis skills, could not analyze words phonetically, read words better in context, made frequent semantic substitution errors (i.e., gave words related conceptually but not phonetically to the original word), and relied on graphic cues such as first and last letters and length. The crucial identifying feature of the dysphonetic subgroup was phonetically inaccurate misspelling.

The Dyseidetic dyslexic appeared to have basic deficits in the visual channel, read analytically through a process of phonetic analysis and synthesis, read laboriously and had a very limited sight vocabulary. The main feature of the dyseidetic subgroup was phonetically accurate misspelling.

The Mixed Dysphonetic-Dyseidetic dyslexic was severely handicapped. Such children experienced difficulty in using graphic and phonic cues in reading and were deficient in both gestalt and analytic processes. Misspellings were bizarre.

Critique of Clinical Inferential Subgroups

The internal validity of the clinical inferential subgroups has not been demonstrated. Attempts to cross-validate Boder's (1973) subgroups were not able to classify all of the disabled readers sampled (Camp & Dolcourt, 1977; Holmes & Peper, 1977). Ingram et al. (1970) and Liberman et al. (1971) did not attempt to cross-validate their findings. The patterns of errors identifying subgroups of adult alexia have not been investigated among disabled readers.

The subgroups proposed on the basis of patterns of reading errors were limited to errors made on word lists.

Reading words in isolation provides a limited number of cues compared to reading words in context and taps only a narrow aspect of reading. In addition, the error classifications tended to be gross, vague and without reliability data.

Boder's (1973) classification system is one of the most comprehensive attempts to identify subgroups of disabled readers on the basis of reading and spelling characteristics. However, her original procedures were not standardized and replication studies vary in their application of her criteria. Attempts to standardize the procedures indicated that only the spelling errors could be reliably identified (Camp & Dolcourt, 1977). Boder's view that spelling strategies reflect reading strategies has been challenged (e.g., Frith, 1980). The relationship between spelling errors and reading errors must be examined in more depth. Boder's clinical observations of the relationship between reading and spelling strategies among disabled readers require systematic study.

Summary

Methodological problems weaken the usefulness of subgroups identified on the basis of reading and spelling characteristics. In the studies reviewed, samples of disabled readers varied widely in age, in sex distribution and in the severity of reading deficit. Sample sizes tended to be small. Statistical analyses were simple or non-existent. Reading assessments tended to be unidimensional, sampling narrow aspects of reading. The characteristics of reading and spelling behaviour used to classify the disabled readers in subgroups tended to be vague and lacked standardization. Internal validity of the subgroups was not demonstrated. Cross-validation of the various classification systems has not been successful, or has not been attempted.

The subgroups formed were not validated convincingly against criteria external to the classification criteria. The rationally defined subgroup studies attempted to relate the classification criteria to oral reading strategies and the subgroups appeared to differ on the external reading criteria as well as the defining criteria. However, sample sizes were small and statistical verification was weak. Clinical inferential subgroups were not validated against reading characteristics external to the classification variables.

None of the studies attempted to validate the distinctiveness of the subgroups on the basis of nonreading variables, such as cognitive, perceptual and linguistic characteristics. Thus, the extent to which the classification criteria identify subgroups which are in fact distinct and homogeneous has not been established. If the subgroups differ systematically in reading strategies, in response to remedial strategies and in performance on cognitive, perceptual and linguistic tasks, then the classification system, or systems, will have greater relevance to questions of etiology, identification, prevention, prognosis and intervention in reading disabilities. The few studies considering both reading and/or spelling and nonreading characteristics of subgroups of disabled readers are reviewed in the next chapter.

IV. The Interface Between Reading and Spelling Characteristics and Nonreading Characteristics of Disabled Readers

In the previous two chapters, attempts to identify homogeneous subgroups of disabled readers on the basis of performance on a multitude of nonreading psychological and neuropsychological tasks and on the basis of reading and/or spelling characteristics were reviewed. It was argued that subgroups characterized by distinctive patterns of performance on nonreading tasks must be validated against external reading criteria to contribute significantly to the identification, remediation and prognosis of reading disabilities. Similarly, if subgroups based on reading and/or spelling characteristics are shown to differ systematically on nonreading correlates of reading disability, they may then advance understanding of the processes associated with reading disability in individual children. Such information will be relevant to issues of etiology, identification, remediation and prognosis. The limited attempts to interface the two approaches to reading disabilities are reviewed in the present chapter.

A. Rationally Defined Subgroups

Visual-motor Integration and Reading Errors

Park (1978) attempted to interface performance on tests of visual-motor integration with reading errors involving visually similar letters presented in isolation, in words, and in words in sentence context. Subgroups of disabled readers were defined on the basis of high and low scores on the Beery Visual Motor Integration Test and the Bender Visual Gestalt Test. Both subgroups had difficulty discriminating between reversible letters and made fewer errors when words were presented in context. The low group were poorer readers, made more errors than the high group, and made more letter sequence errors on a sentence task. It was concluded that the findings suggested that common errors made by disabled readers may be due to factors other than visual confusability.

Reading/Spelling Patterns and Processing Strategies

Subgroups based on Boder's (1973) reading and/or spelling patterns have been found to differ on external criteria assessing information processing and perceptual processing strategies (Aaron, 1978; Obrzut, 1979). Dysphonetic disabled readers were deficient in analytic sequential processing (Digit Span) but normal in holistic simultaneous processing (memory for faces) whereas the dyseidetics showed the opposite pattern of performance (Aaron, 1978).

Normal readers and subgroups of disabled readers were compared on a dichotic listening task assumed to assess cerebral dominance for language and auditory recall ability, and on a bisensory memory task assumed to measure auditory-visual integration ability (Obrzut, 1979). The normal and dyseidetic groups had higher levels of performance than the dysphonetic and mixed groups on both tasks. Dyseidetic disabled readers also had higher reading levels than the dysphonetic and mixed groups. It was suggested that dysphonetic and mixed groups of disabled readers experience difficulty in both linguistic (left hemisphere) and spatial (right hemisphere) processing.

Critique of Rationally Defined Subgroups

The significance of the criteria defining the above reading disability subgroups within the population of children with reading disorders has not been established. Difficulty in visual-motor integration may be important for a few disabled readers; however, such difficulty had little relation to reading behaviour (Park, 1978). Boder's (1973) procedures have not been adequately standardized and Aaron (1978) limited his classification criteria to spelling errors which may not reflect differences in reading strategies (Frith, 1980).

Aaron's (1978) sample was small and the number of measures was limited. The observed differences in information processing strategies need to be cross-validated with additional measures assumed to be sensitive to processing strategies. Obrzut (1979) provided evidence which appeared to confirm perceptual processing differences between dysphonetic and dyseidetic disabled readers. In support of Aaron's findings, dysphonetics were deficient in auditory recall on the dichotic listening task. However, dysphonetics were also deficient in visual recall on bisensory memory tasks possibly reflecting a spatial processing difficulty. The interpretation is questionable because the visual presentation of digits permits verbal labeling and may not be a specifically spatial task. The conclusions of Aaron (1978) and Obrzut (1979) are weakened by the questionable construct validity of the tasks used.

Park (1978) used measures of visual-motor integration whereas visual perceptual tests excluding a motor component may be more sensitive to decoding errors related to the visual properties of graphic stimuli. Park (1978) did not control factors which may have influenced the types of errors produced, such as the acoustical similarity and pronounceability of the letters and words, nor was the meaningfulness of the responses on the sentence context task evaluated to determine the effects of contextual constraints. Thus, the materials and analysis may not have been sensitive to the contribution of visual properties to reading errors.

B. Clinical Inferential Subgroups

Reading Characteristics and Inferred Processing Deficiencies

Johnson and Myklebust (1967), Myklebust (1978) and Vernon (1979) attempted to identify subgroups of disabled readers on the basis of their reading characteristics and psychological processes thought to be associated with the various manifestations of reading difficulty. These attempts to interface reading behaviour and psychological processes are based on observations of differences in reading behaviour integrated with research evidence concerning the processing abilities of disabled readers. The classifications were not directly derived from classification research studies.

Myklebust (1978) expanded the auditory and visual dyslexia classifications of Johnson and Myklebust (1967). Two subgroups were added and the psychological processes assumed to underlie the reading difficulties were elaborated: 1) Inner language dyslexics are characterized by good word recognition without comprehension, assumed to be related to an inability to code information at the level of meaning; 2) Auditory dyslexics experience difficulty in relating phonemes to graphemes, assumed to be related to impaired auditory processes thought to be the primary area of disturbance in most disabled readers; 3) Visual dyslexics can usually discriminate letters but they have difficulty in attaining meaning, being unable to symbolize the visual components of words so that they are encoded as words; 4) Intermodal dyslexia involves difficulties in transforming processes in one modality to an equivalent form in the other modality, although auditory and visual processing abilities are adequate.

In Vernon's (1979) view, reading consists of a series of complex skills acquired as a child progresses from the early stages of learning to read to the final stage of fluent reading. Thus, one may classify disabled readers on the basis of the stage of reading in which the development of the reading process breaks down. Vernon listed four classifications of disabled readers: 1) cannot read at all; 2) can read a few simple words but appears to be incapable of comprehending phonic reading; 3) can read simple regular words but does not understand how to manipulate irregular grapheme-phoneme correspondences; 4) can read single words but cannot group words syntactically into phrases. For each subgroup, underlying processes which may account for the reading difficulties were described. These classifications were based upon a synthesis of data relevant to differences in reading behaviour among disabled readers and to the inferred processes which may be implicated.

Reading/Nonreading Patterns and Processing Strategies

Pirozzolo (1979) considered reading and nonreading characteristics of subgroups of disabled readers. Reading disabled boys were classified as "audio-linguistic" or "visual-spatial" on the basis of a clinical evaluation of behavioural descriptions, writing samples and psychological and neuropsychological test performance. The eye movements and accuracy of word recognition of the subgroups were compared during tachistoscopic tasks. The audio-linguistic subgroup did not show lateral asymmetry for word recognition suggesting less efficient linguistic processing in the left hemisphere. Eye movements were similar to those of normal readers. The visual-spatial subgroup showed the normal right field superiority for word recognition but eye movements differed from those of normal readers. It was suggested that the visual-spatial subgroup had impaired visual-motor processing and a maturational lag in control of visual-motor spatial information processing.

Critique of Clinical Inferential Subgroups

To the writer's knowledge, there have been no empirical classification studies applying the classification schemas of Myklebust (1978) or Vernon (1979) to samples of disabled readers. The psychological processes thought to be related to differences in reading behaviour have been inferred, primarily through the integration of data from single-syndrome research studies. The processes have not been directly investigated among subgroups formed on the basis of proposed subgroup classification criteria. The criteria for identifying the subgroups in actual samples of disabled readers would need to be operationalized in more explicit terms than the descriptions provided by the authors.

Pirozzolo (1979) based his conclusions on a small sample of 24 11-year-old reading disabled boys. Generalizability of the findings was thus limited. The clinical inferential basis for the subgroup classifications was not demonstrated empirically. The subgroups were not shown to differ on the classification variables using statistical or other procedures. Of critical importance is the inference of hemispheric processing differences on the basis of perceptual asymmetries. Such inferences have been questioned (e.g., Kinsbourne & Hiscock, 1978).

C. Statistically Derived Subgroups

Cluster Analysis

A study by Lyon and Watson (1981) involved a limited interface of nonreading and reading characteristics of statistically derived subgroups of disabled readers. Hierarchical cluster analysis was applied to a battery of nonreading linguistic and perceptual measures similar to the battery of Mattis et al. (1975). Six subgroups were identified within a sample of 100 children with reading problems drawn from a school population. Cluster analyses of raw scores and of standard scores based on the average performance of a sample of 50 normal readers yielded the same six subgroups which had high coverage, classifying 94% of the 100 disabled readers.

The internal validity of the subgroups was thus demonstrated by the second cluster analysis of standard scores as well as by analyses of variance and a discriminant function analysis which indicated significant differences among the subgroups on the classification variables. Visual-motor integration and following directions contributed most to the subgroup differences.

Subgroup 1 had mixed deficits in language and visual perception. Subgroup 2 had milder mixed deficits. Subgroup 3 demonstrated a language disorder with deficits in language comprehension and sound blending. Subgroup 4 manifested a visuoperceptive disorder and was unexpectedly the largest subgroup. Subgroup 5 was characterized by difficulty in the retention, synthesis and expression of sound and word sequences. Subgroup 6 had a normal diagnostic profile with reading problems possibly associated with social, motivational or pedagogical factors.

The external validity of the subgroups was evaluated against reading measures. Analyses of variance indicated significant differences among the subgroups on measures of word recognition and reading comprehension. The normal diagnostic profile of Subgroup 6 was associated with significantly higher levels of word recognition and reading comprehension compared with all other subgroups. The lowest reading levels were found for Subgroup 1 (mixed deficits) and Subgroup 5 (auditory sequencing deficits).

Lyon, Reitta, Watson, Porch and Rhodes (1981) evaluated the above subgroups against spelling and family history variables. Spelling performance resembled reading performance with Subgroup 1 making the most spelling errors and Subgroup 6 making the fewest. Subgroups 3 and 5 made more spelling errors than Subgroups 2, 4 and 6. No interpretable subgroup differences were found for family history variables.

Q Factor Analysis

A series of studies conducted by Doehring and his associates represent an integrated approach to the statistical classification of subgroups of disabled readers, the assessment of the stability and internal validity of the subgroups, and the validation of the subgroups against external perceptual, cognitive and linguistic criteria.

Doehring and Hoshko (1977) used Q factor analysis to identify subgroups of disabled readers on the basis of differential patterns of performance on reading and "reading-related" skills which included oral reading measures, visual matching tasks, matching of spoken and written stimuli, and visual scanning. Three subgroups were identified within a sample of 34 children with reading problems: 1) Subtype 1 was characterized by deficits in the oral reading of words and syllables which were attributed to a high-level linguistic deficit; 2) Subtype 2 was characterized by deficits in the matching of auditory and visual letters thought to be indicative of intersensory integration problems; 3) Subtype 3 was characterized by deficits in auditory-visual matching of words and syllables in contrast to proficient performance in matching individual letters, possibly related to difficulty in phonological processing and in the perception of temporal order. Coverage was high with 31 of 34 children classified. Only four children had high loadings on more than one factor indicating the independence of the subgroups.

A form of external validation of the three subgroups was attempted. Teachers' evaluations of the difficulties experienced by the children were related to the characteristics of the subgroups. Subtype 1 had comprehension difficulties. Subtype 2 required training in comprehension, visual-auditory association and oral expression. Subtype 3 experienced difficulty in phonetic analysis, written sequencing and sound-letter blending.

Further studies by Doehring and his associates attempted to assess the stability and internal validity of the subgroups, to validate the statistical procedures used, and to directly investigate the perceptual, linguistic and cognitive skills of the subgroups. Doehring, Hoshko and Bryans (1979) assessed the stability of statistical classifications of reading problems based upon the 31 skills assessed by Doehring and Hoshko (1977). When normal and problem readers of the same age were combined, the three reading problem subgroups identified by Doehring and Hoshko (1977) were well-preserved and thus appeared to have internal validity. However, the normal readers could not be classified in consistent subgroups.

Doehring et al. (1979) compared the results of different statistical classification techniques applied to the data of Doehring and Hoshko (1977). Three methods of cluster analysis and a Q factor analysis yielded different subgroups. However, McQuitty's method of cluster analysis and the Q factor analysis showed agreement with 13 misclassifications among 57 children. It was concluded that the results supported the stability of the Q factor analysis classifications of reading problems. However, the disagreement in subgroups produced by some cluster analyses underscores the need for caution in applying and interpreting these procedures. Validation of subgroups is thus particularly important when the results appear to be sensitive to the techniques, sample and measures used.

The important issue of the external validity of the subgroups of disabled readers was addressed in a study by Doehring, Trites, Patel and Fiedorowicz (1981) which combined comprehensive assessments of reading-related skills, language test performance and neuropsychological test performance of 88 disabled readers aged eight to 27 years. First, Q factor analysis identified three subgroups of disabled readers on the basis of reading skill across Doehring and Hoshko's (1977) 31 tests: Type O, an oral reading deficit; Type A, poor association of spoken and written stimuli; and Type S, a letter sequence deficit characterized by poor matching of words and syllables compared with the matching of individual letters. The three subgroups were highly similar to those identified by Doehring and Hoshko (1977) supporting the internal validity of the classifications.

Q factor analysis applied to tests of phonological, syntactic and semantic language abilities identified two language subgroups. Both subgroups were poor in phonemic segmentation and morphophonemic knowledge. One subgroup also demonstrated poor oral repetition and the other demonstrated poor serial naming and comprehension. There was poor correspondence between the two types of language disability and the three types of reading disability. When the reading-related and language data were combined in a single analysis, four joint reading-language classifications emerged.

Q factor analysis of an extensive battery of intelligence and neuropsychological tests did not yield interpretable subgroups. The reading skill profile subgroups did not appear to have different distinctive patterns of performance on the neuropsychological test battery.

Critique of Statistically Derived Subgroups

Lyon and Watson (1981) made an important contribution to multiple-syndrome reading disability research by empirically identifying subgroups of disabled readers within a public school sample of a narrow age range, thus addressing problems associated with clinic referrals and the effects of age differences in other studies (e.g., Doehring et al., 1981; Mattis et al., 1975). In contrast to other classification studies which reported a small subgroup with visuoperceptive difficulties (e.g., Mattis et al., 1975), the largest subgroup identified by Lyon and Watson (1981) was characterized by visuoperceptive deficits. This unexpected finding points to the need to cross-validate the findings at different age levels and with different samples of public school children.

Statistical procedures evaluating the internal validity of the subgroups formed by cluster analysis of several nonreading measures were also a strength of the Lyon and Watson (1981) study. The evaluation of external validity, however, was limited to a brief assessment of levels of word recognition and comprehension which provided little information about differences in the reading characteristics of the subgroups. Lyon et al. (1981) attempted further evaluation of the external validity of the subgroups against spelling measures and family history variables. Although the number of spelling errors differentiated the subgroups, no information was provided about the types of spelling errors made by the various subgroups.

The integrated research by Doehring and his associates represents the best illustration of the multiple-syndrome paradigm applied to reading disability research to date. The subgroups of disabled readers based on the 31 reading and reading-related measures were identified in independent samples of disabled readers (Doehring & Hoshko, 1977; Doehring et al., 1981). The reliability and internal validity of the subgroups and the reproducibility of results using Q factor analysis were thus supported.

The failure of Q factor analysis to identify a subgroup of normal readers may reflect a problem in the statistical procedure. Q factor analysis is not sensitive to differences between disabled readers and good readers who share similar patterns of abilities but at different levels of proficiency. Alternatively, it may be that normal readers do not form homogeneous subgroups in terms of the particular reading-related skills measured by Doehring and his associates.

The application of different statistical classification techniques to the same data provided support for Q factor analysis over more variable cluster analytic techniques (Doehring et al., 1979). One may, however, question the standard against which the cluster analysis classifications were compared, i.e., they were evaluated against the results of a Q factor analysis. The choice of standard may be valid in that the Q factor analysis results were replicated across samples of disabled readers; however, the Q factor analysis classifications have not been adequately validated against external criteria.

Doehring and Hoshko (1977) attempted to provide external validation of the reading subgroups by obtaining independent estimates of reading skills from teachers. The subjective estimates provided descriptive data which were not evaluated statistically. The subgroups were compared with subgroups identified by other researchers. However, in view of the weaknesses in studies attempting to identify reading disability subgroups cited earlier, such comparisons are a weak source of validation.

Doehring et al. (1981) undertook to validate the subgroups against external linguistic and neuropsychological criteria. Attempts to interface the subgroups formed on the basis of the different measures were not successful. A complex interaction was observed between the reading-related and language skill tests. Patterns of performance on the neuropsychological tests did not appear to correspond clearly to the reading skill subgroups. Methodological characteristics of the study may have contributed to the lack of clarity of the findings. The sample of clinic referrals covered a wide age range which likely increased the sample heterogeneity. In addition, the reading-related skills battery may not be sensitive to important differences in the characteristics of the reading behaviour of disabled readers. Doehring et al. (1981) recommended the use of a reading assessment which more directly samples the skills used in functional reading.

D. Summary

The attempts to interface the reading and spelling characteristics and the nonreading characteristics of subgroups of disabled readers reviewed in the present chapter are examples of the multiple-syndrome paradigm recommended for reading disability research (Doehring, 1978). The appropriateness of the multiple-syndrome paradigm was supported by the data presented in Chapters II and III which confirmed the heterogeneity of disabled readers in terms of reading and spelling behaviour and nonreading characterisitcs. The need to combine the two approaches to the study of reading disabilities was highlighted in the criticisms of classification systems which were limited to nonreading characteristics (Chapter II) or to reading and spelling characteristics (Chapter III).

The studies reviewed in the present chapter recognized the need to interface actual reading behaviour with evaluations of the processes thought to be involved in reading difficulty. However, the assessments of reading and spelling characteristics tended to be limited. Frequently, the assessments of nonreading variables were narrow. The sample selection criteria have been criticized. Thus, at present, methodological problems limit the applicability of the classification systems in research and remediation. A current need in research in the field of reading disabilities appears to be the application of objective statistical classification procedures to a comprehensive assessment of reading characteristics and to a wide range of nonreading variables to determine the most meaningful and valid classification system for identifying homogeneous subgroups of disabled readers within a school population.

V. The Study

In recent years, complex research models which accommodate the heterogeneity of reading disorders have been recommended for use in reading disability research (Appelbee, 1967; Doehring, 1978; Wiener & Cromer, 1967). Complex models assume that more than one syndrome of reading disability is possible, each associated with different patterns of reading and nonreading skills. It is hoped that the identification of subgroups of disabled readers will contribute to improvements in identification, remediation, and prediction of outcome of reading disabilities (Benton, 1978). Important goals of such research include improved definitions for research and treatment (Hagin, Beecher & Silver, 1982; Rourke & Gates, 1981) and the development of syndrome-specific treatment programs (Mattis, 1981).

While the potential importance of identifying subgroups of disabled readers is widely recognized, research in this area has been limited by the classification approaches used, the selection of subjects for study, the selection of reading measures and nonreading measures, and particularly in the failure to adequately evaluate the coverage, internal validity and external validity of the classification solutions. Classification approaches currently in use, i.e., [illegible]tional definition, clinical inferential and statistical approaches, each have weaknesses. Although statistical classification approaches overcome many difficulties associated with other approaches (e.g., subjectivity, visual inspection of complex data sets, a priori assumptions about the number and nature of the subgroups), weaknesses associated with current statistical classification procedures require that the subgroups formed be carefully evaluated in terms of coverage, internal validity and external validity.

External validation of subgroups requires that they be shown to differ on variables external to the variables used to form the subgroups. For example, subgroups formed on the basis of oral reading variables may be externally validated against other standardized reading measures, or against nonreading variables. Within a multiple-syndrome model, external validation of these subgroups against nonreading variables is of particular interest as the model assumes that subgroups of disabled readers are characterized by unique patterns of both reading characteristics and nonreading characteristics.

The relationships between reading and nonreading characteristics among subgroups of disabled readers have important implications for our understanding of reading disabilities. If subgroups formed on the basis of reading characteristics are shown to differ on nonreading variables such as cognitive, linguistic and perceptual characteristics, then the classification system may have greater relevance to questions of etiology, identification, prevention, prognosis and intervention in reading disabilities. Conversely, if disabled readers are classified into subgroups on the basis of nonreading test performance, then external validation against reading criteria is important. If the nonreading performance differences among the subgroups are systematically related to differences in reading performance, the classifications will contribute greatly to the understanding of reading disabilities and to questions of etiology, identification, prevention, prognosis and, particularly, intervention.

External validation of subgroups of disabled readers thus involves the interface of reading and nonreading characteristics of disabled readers. A few recent studies have attempted the interface of reading and/or spelling characteristics with nonreading characteristics of disabled readers. For example, studies reviewed in Chapter IV provided some indication that there may be systematic relationships between information processing strategies and types of spelling errors (Aaron, 1978; Obzrut, 1979), and between language and perceptual test performance and reading achievement (Lyon & Watson, 1981), and that there may be a complex interaction between reading-related skills, language test performance and neuropsychological test performance among disabled readers (Doehring et al., 1981).

Although these studies included the consideration of both reading/spelling and nonreading characteristcs of disabled readers, several problems limit the applicability of the classification systems in research and remediation. Problems included sample selection criteria and limited assessments of the characteristics of the subgroups. For example, the sample in the Doehring et al. (1981) study was comprised of clinic referrals covering a wide age range. Lyon and Watson (1981) employed a nonclinic school sample of a narrow age range but included only a limited assessment of reading characteristics. The studies of Aaron (1978), Obzrut (1979) and Park (1978) were particularly limited by narrow assessments of nonreading characteristics. In addition to the problems noted above, all of the classification studies reviewed have weaknesses associated with the particular approach to classification which was employed.

A current need in research in the field of reading disabilities appears to be a classification study which examines the interface between reading and nonreading characteristics of subgroups identified in a nonclinic sample of disabled readers. The disabled readers should be drawn from a narrow age range to control for the effects of varying chronological ages and developmental levels. Comprehensive assessments of both reading and nonreading characteristics are required to cover the wide range of possible differences among disabled readers. Statistical classification procedures are most appropriate to handle the complex data sets. However, in view of weaknesses associated with such procedures, it must be demonstrated that the classification solutions have adequate coverage, internal validity and external validity. The combination of comprehensive reading and nonreading assessments within a classification study provides data important for the external validation of the subgroups.

A. Statement of the Problem

The central problem addressed in the present study involved the interface between reading and nonreading characteristics of subgroups identified within a public school sample of 9- and 10-year-old children who manifest difficulty in reading. Examination of the problem included sampling across a wide range of both reading and nonreading characteristics of the disabled readers. The use of various strategies in reading connected text is currently emphasized in reading research. Thus, the reading assessment in the present study included in-depth quantitative and qualitative analyses of oral reading samples, as well as standardized tests of word identification, word attack and passage comprehension. In view of previous classification studies which emphasized the importance of spelling characteristics of disabled readers, a qualitative analysis of spelling was also included to provide information about phonetic accuracy in spelling and its relationship to reading.

To prevent bias towards any particular nonreading characteristics of disabled readers, the assessment sampled across a comprehensive range of skill areas including IQ, language, memory, sequencing, perceptual, visual-motor and motor functioning. Teachers' ratings of classroom behaviour and arithmetic achievement provided information about additional areas of performance.

Objective statistical classification procedures were used to form subgroups. In view of weaknesses associated with such procedures, issues of coverage, internal validity and external validity were examined. Internal validation involved the use of various statistical classification procedures, data manipulation, and statistical tests and graphic plots of differences among subgroups.

The central interest in the interface between reading and nonreading characteristics of subgroups of disabled readers involved evaluation of the external validity of the subgroups. Subgroups formed on the basis of reading characteristics were compared with subgroups formed on the basis of nonreading characteristics. Subjects clustering together on each type of data were compared to determine whether similar subgroups were derived on the basis of the two types of data. The external validity of subgroups formed on the basis of reading data was evaluated against nonreading performance characteristics, and subgroups formed on the basis of nonreading characteristics were evaluated in terms of the distinctiveness of their reading characteristics.

Essentially, the present study endeavoured to use statistical classification techniques to identify internally valid subgroups of disabled readers on the basis of reading measures, and also on the basis of nonreading measures. The interface between these characteristics was examined, particularly as it related to the issue of the external validity of the subgroups.

B. Method

Subjects

Forty-nine disabled readers, 33 males and 16 females, were selected from 18 elementary schools in the Edmonton Public School System. Forty-five of the subjects had been in resource rooms; 29 were attending resource rooms at the time of testing. Descriptive data are included in Table V.1. Selection was made on the basis of the following criteria:

1. Reading level below age expectation was based on achievement indices of the *Woodcock Reading Mastery Tests* (Woodcock, 1973) which are defined as the difference between the child's mastery score and the mastery score expected at his/her age. For inclusion in the study, subjects were required to have a negative achievement index greater than or equal to 20 on the Word Identification test of the *Woodcock* and a negative achievement index of one or more points on the Passage Comprehension test of the *Woodcock*. On the *Woodcock* tests, a negative achievement index of -20 to -29 indicates relative mastery of 26% to 50% at grade level and a percentile rank of four to eight. A negative achievement index of -30 or more indicates 25% or less mastery and a percentile rank of one to three.

TABLE V.1
SAMPLE CHARACTERISTICS

	CHRON. AGE (mos.)	ACT. GRADE	EXP. GRADE[1]	WISC-R		WOODCOCK READING MASTERY TESTS		
						Word Ident.		Passage Compreh.
				VIQ	PIQ	Expected Grade Discrep.[2]	Achievement Index[3]	Achievement Index[3]
$\overline{X}$	120.1	4.4	5.0	96.8	104.2	1.8	69.2	83.6
SD	6.7	0.7	0.6	8.9	9.8	0.4	10.5	8.0
Range	108 to 132	2.7 to 5.5	3.5 to 5.8	78 to 117	87 to 123	0.8 to 2.9	34 to 80	69 to 98

1. Grade placement expected on the basis of age.
   Twenty-eight subjects had failed a grade.

2. The discrepancy is based upon the subject's age expected grade level minus the grade score for achievement in word identification.

3. Scores have been subtracted from 100 so that higher scores indicate higher achievement and a score of 100 indicates performance at age expected grade level.

2. Regular class placement, possibly with resource room help.
3. Age nine years to ten years and eleven months at the time of testing.
4. *Revised Wechsler Intelligence Scale for Children (WISC-R)* (Wechsler, 1974) Verbal and/or Performance IQ greater than or equal to 90, and a score greater than or equal to 70 on the lower IQ scale.
5. No evidence of uncorrected vision, no history of hearing problems, no history of major emotional problems and no documented history of neurological trauma or illness.
6. English as the mother tongue.
7. Parents or guardians of potential subjects were informed of the study and consent for participation was obtained.

Measures

Two types of measures were obtained: a reading and spelling assessment and an assessment of nonreading performance. The reading and spelling assessment included the evaluation of word identification, word attack and passage comprehension skills, an analysis of oral reading of connected text and quantitative and qualitative assessments of spelling achievement. The nonreading assessment included psychological and neuropsychological tests and teachers' ratings. The psychological and neuropsychological tests evaluated five main areas, namely, intellectual, language, perception, memory/sequencing, and motor functioning.

Teachers' ratings evaluated each child's arithmetic achievement and classroom behaviour.

I. Reading and Spelling Assessment

The measures included in the reading and spelling assessment are listed in Table V.2. The measures are described briefly below. The details of the scoring procedures are presented in a later section.

(a) Reading Measures. The reading measures were selected to yield a comprehensive evaluation of several aspects of reading performance. Standardized tests and the analysis of samples of oral reading behaviour were included.

Three standardized tests were selected from the *Woodcock Reading Mastery Tests*. The Word Identification test measured recognition of words presented in word lists; the Word Attack test assessed skill in reading nonsense words which follow the rules of English orthography; and, the Passage Comprehension test evaluated comprehension of phrases and sentences using a cloze procedure. Achievement index scores were used to designate the level of achievement on each of these tests.

An oral reading analysis was included to provide information about each child's use of the cues available in connected text. Samples of oral reading provide information about the strategies children use in functional reading. Each child read two passages of connected text orally. Each passage contained approximately 250 words and was followed by five comprehension questions. The oral reading was timed

TABLE V.2
MEASURES OF THE READING AND SPELLING ASSESSMENT

Woodcock Reading Mastery Tests (Woodcock, 1973)

- Word Identification
- Word Attack
- Passage Comprehension

Oral Reading Analysis

- Speed Of Oral Reading (Words Per Minute)
- Oral Passage Comprehension
- Error Rate
- Self-corrections
- Repetitions
- Error Types:
    - Insertions
    - Omissions
    - Word Order Reversals
    - Letter Order Reversals
    - Substitutions:
        - Same Stem
        - Same Affix
        - Other Meaningful Word
        - Nonsense Word
- Qualitative Scales:
    - Graphic Similarity Scale
    - Phonic Similarity Scale
    - Syntactic Acceptability Scale
    - Semantic Acceptability Scale
    - Meaning Scale

Edmonton Spelling Ability Test

- Grade Level
- Grade Discrepancy Score
- Percent Of Phonetically Accurate Spelling Errors

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and recorded on tape for quantitative and qualitative analyses.

The quantitative scores included the speed of oral reading, oral reading passage comprehension, the frequency of self-corrections, of repetitions and of various types of oral reading errors. The types of errors were taken from Hood (1975) and included: omissions, insertions, word order reversals, letter order reversals, and substitutions including substitutions involving the same stem, the same affix, another meaningful word, or a nonsense word. The operational definitions of these error types are included in Appendix A.

The substitution errors and letter reversal errors were evaluated qualitatively in terms of their visual and sound similarity to target words in the passage, their contextual appropriateness within the passage, and their effect on the meaning of the passage. Each letter reversal and substitution error was scored on five qualitative scales, namely, the Graphic similarity scale, the Phonic similarity scale, the Syntactic acceptability scale, the Semantic acceptability scale, and the Meaning scale.

(b) Spelling measures. Spelling was assessed by the *Edmonton Spelling Ability Test* which yields a spelling grade level. As an indication of the severity of spelling difficulties, a spelling grade level discrepancy score was calculated. The child's grade level achieved on the spelling test was subtracted from the grade level expected on the basis of his/her age. A qualitative analysis of each child's first ten misspellings assessed the phonetic accuracy of spelling errors.

II. Nonreading Assessment

The nonreading assessment included psychological and neuropsychological measures and teachers' ratings of behaviour. The extensive battery sampled several areas of functioning: intelligence; language; auditory, visual and tactile perception; memory and sequencing; and, visual-motor and motor skills. Arithmetic achievement and classroom behaviour were rated by teachers. The areas of functioning that were of interest are listed in Table V.3 along with the names of the specific tests thought to involve such processes. Detailed descriptions of the tests, of the scores used, and of the processes thought to be involved are included in Appendix B.

The processes sampled by the nonreading assessment are described here in general terms. Individual intelligence testing provided both verbal and nonverbal measures. The discrepancy between Verbal and Performance IQ was considered. IQ subtests were also examined in relation to various processes of interest as shown in Table V.3.

Language testing sampled expressive, or productive, and receptive, or processing, skills. Three levels of language functioning were included: phonological, syntactic and semantic.

TABLE V.3
PROCESSES ASSESSED AND RELEVANT TESTS

PROCESS	TEST
A. INTELLIGENCE	
i. Verbal IQ	*WISC-R*[1] Verbal Subtests
ii. Performance IQ	*WISC-R* Performance Subtests
B. LANGUAGE	
i. Phonological Level	
Processing	
--Auditory Discrimination	*CELF*[2] #12: Processing Speech Sounds
--Sound Blending	*ITPA*[3] Sound Blending
Production	
--Motor Speed	*CELF* #8: Producing Names On Confrontation
ii. Syntactic Level	
Processing	
--Morphology And Syntax	*CELF* #1: Processing Word And Sentence Structure
--Logico-grammatical Relationships	*CELF* #4: Processing Relationships And Ambiguities
Production	
--Morphology And Syntax	*ITPA* Grammatical Closure
--Syntax	*CELF* #10: Producing Model Sentences
iii. Semantic Level	
Processing	
--Receptive Vocabulary	*PPVT-R*[4]
--Logico-grammatical Relationships	*CELF* #4: Processing Relationships And Ambiguities
--Oral Directions	*CELF* #5: Processing Oral Directions
Production	
--Expressive Vocabulary	*WISC-R* Vocabulary
--Verbal Concepts	*WISC-R* Similarities
--Word-finding (Anomia)	*CELF* #8: Producing Names On Confrontation
--Verbal Fluency	*CELF* #7: Producing Word Series
	CELF #9: Producing Word Associations
C. MEMORY/SEQUENCING	
i. Auditory	
--Verbal Sequential	*WISC-R* Digit Span
	CELF #5: Processing Oral Directions
	CELF #7: Producing Word Series
	CELF #10: Producing Model Sentences
--Verbal Non-sequential	*CELF* #9: Producing Word Associations
--Non-verbal Sequential	Rhythm Test (Seashore, Lewis & Saetveit, 1960)
ii. Visual	
--Verbal Sequential	Trail-making (Reitan, 1958)
--Non-verbal Sequential	*WISC-R*: Picture Arrangement
	WISC-R: Coding
	Knox Cube Test (Arthur, 1947): Immediate Recall, Delayed Recall
--Non-verbal Non-sequential	*BVRT*[5] (Administration A)

(CONTINUED...)

TABLE V.3 (Continued)
PROCESSES ASSESSED AND RELEVANT TESTS

PROCESS	TEST
D. PERCEPTION	
i. Auditory	
--Auditory Discrimination Of Speech Sounds	*CELF* #12: Processing Speech Sounds
--Non-verbal Auditory Perception And Sequencing	Rhythm Test
ii. Visual	
--Visual-motor Integration	*WISC-R*: Coding
	BVRT (Administration C)
	Trail-making
	Grooved Pegboard (Matthews, 1977)
--Visual-spatial	*WISC-R* Picture Completion
	WISC-R Object Assembly
	WISC-R Block Design
	Right-left Discrimination
iii. Tactile	
--Tactile Recognition	Finger Localization (Reitan, 1965)
--Tactile Discrimination	Finger-tip Number Writing (Reitan, 1965)
E. MOTOR	
i. Fine Motor, Manual Dexterity	Grooved Pegboard
	WISC-R Coding
ii. Gross Motor, Speed	Finger-tapping (Reitan, 1959)
F. BEHAVIOUR RATINGS	
i. Conduct Problems	Conners Teacher Questionnaire
ii. Inattentive Passive	(Conners, 1969)
iii. Tension-anxiety	
iv. Hyperactivity	

1. Wechsler Intelligence Scale For Children - Revised (Wechsler, 1974)
2. Critical Evaluation Of Language Functions (Semel and Wiig, 1980)
3. Illinois Test Of Psycholinguistic Abilities (Kirk, McCarthy and Kirk, 1968)
4. Peabody Ricture Vocabulary Test - Revised (Dunn and Dunn, 1981)
5. Benton Visual Retention Test (Benton, 1963)

Several types of stimuli were included in memory and sequencing tasks: auditory and visual; verbal and nonverbal; and, meaningful and nonmeaningful. Immediate and delayed recall, and short term and long term memory were considered.

Auditory, visual and tactile perception were sampled. Auditory tasks included the perception of speech sounds and of nonverbal sequential rhythms. Visual-spatial perception and visual-motor integration were involved in several tasks listed in Table V.3. Sensory perception tasks also assessed tactile recognition and discrimination.

The motor performance component of the assessment included fine motor coordination and manual dexterity. Speed of gross motor movement was also assessed.

Teachers completed the Conners Teacher Questionnaire (Conners, 1969) which assesses four areas of classroom behaviour: conduct problems, inattentive-passive behaviour, tension-anxiety and hyperactivity. Arithmetic achievement was rated by the teachers as normal, borderline or underachievement.

Procedure

Potential subjects were selected from resource rooms and/or regular classes on the basis of teachers' recommendations and the results of standardized tests of IQ and achievement, where available. Children were tested individually by the Experimenter in their own schools during January through April.

The *Woodcock* reading tests and the *WISC-R* were administered first to determine if the child met the reading level and IQ criteria for inclusion in the study. Each child who met all of the subject selection criteria was seen two or three times, for approximately 75 to 90 minutes each time. The third session was required if recent *WISC-R* data were not available. If the *WISC-R* had been administered within one-and-a-half years from the time of the present testing, the scores on file were used. Missing subtests were administered. The Digit Span subtest was administered to all children at the time of testing to provide a current measure of auditory verbal sequential memory. Where possible, the sequence of tests specified in Appendix C was maintained and the two or three sessions occurred within a two week period for each child. Changes were made to accommodate special circumstances (e.g., absenteeism, illness, excessive fatigue, school functions).

Oral reading samples were obtained near the beginning of the second or third session. The oral reading analysis required that each subject read two passages at an error rate of six to 11 miscues per hundred words, i.e., a 6% to 11% error rate. To obtain the appropriate oral reading samples, one of the graded reading passages (see Appendix D) was selected to correspond to the grade level indicated by the Reading Grade score (90% mastery) of the *Woodcock* Word Identification test. The child was required to read this passage, and easier or more difficult passages until s/he had read two passages at an error rate of 6% to 11%. Five comprehension questions followed each story. The reading samples were timed, recorded on tape and scored as described in the Scoring section.

Teachers were asked to complete a questionnaire which included an evaluation of arithmetic achievement and classroom behaviour. The questionnaires were collected upon completion of the assessments of children in the school.

The data were scored following the procedures described in the next section. Inter-rater reliability was evaluated for the qualitative analyses of oral reading errors.

Scoring

I. Reading and Spelling Assessment

(a) *Woodcock Reading Mastery Tests*. Raw scores on the Word Identification, Word Attack and Passage Comprehension tests of the *Woodcock Reading Mastery Tests* were converted to grade level equivalents and to mastery scores. A child's level of achievement was determined by comparing his/her mastery score to the mastery score expected of a child of that age, i.e., to his/her age expected grade level. An achievement index was calculated by subtracting the mastery score at age expected grade level from the child's mastery score. A negative achievement index reflected achievement below the grade level expected on the basis of the child's age. An index of -20 to -29 corresponds to a percentile rank of four to eight, and -30 or more corresponds to a percentile rank of one to three. The achievement indices were adjusted to remove the negative sign. Since all indices were below 100, each index was subtracted from the constant 100 such that a score of 100 reflected performance at the grade level expected on the basis of the child's age. Thus, as scores approached 100, they indicated higher levels of achievement.

(b) Oral Reading Analysis. Scoring of the oral reading samples involved quantitative and qualitative analyses. The quantitative scores included reading speed, error rate, repetitions, and the frequency of self-corrections and of each error type. Detailed procedures for obtaining scores on the measures are described below.

1. Speed of oral reading was expressed as the number of words per minute (WPM) calculated on the basis of the total time taken to read the passage.
2. Error rate was based on the number of errors per hundred words read. The errors counted to determine the error rate included omissions, insertions, letter order reversals and substitutions. Errors on simple words (e.g., a, the, and) and repeated errors were not included in the calculation of the error rate. The number of relevant errors during the oral reading of a passage was divided by the number of words in the passage and multiplied by 100 to yield the error rate expressed as a percent.
3. The frequency of self-corrections was expressed as a

percent of the total errors on the passage.

4. The total number of repetitions during the oral reading of a passage was recorded.
5. The frequency of each type of oral reading error was calculated. The types of errors scored were based upon Hood's (1975) definitions of insertions, omissions, letter order reversals, word order reversals, and substitution categories of same stem, same affix, other meaningful word and nonsense word (see Appendix A). Scores were expressed as percentages of the total errors on the passage including repeated errors and errors on simple words.

A qualitative analysis of all substitution errors and letter reversal errors included five qualitative scales with scores ranging from 0 to 4. The scales were derived from the qualitative scoring systems of Goodman and Burke (1972), Burke (1976) and Pflaum (1979) and are described in Table V.4. For each passage, converted scale scores were computed. The total score on each scale was divided by the total score possible for that scale based on the number of substitution and letter reversal errors for the passage. The converted scores were then expressed as percentages. For example, if a subject made 20 substitution and letter reversal errors on a passage, s/he could obtain a maximum score of 80 on the Graphic similarity scale (i.e., 20x4=80). If the subject actually obtained a total score of 40 on the Graphic similarity scale, summing over the score assigned to

TABLE V.4
SCALES FOR THE QUALITATIVE ANALYSIS OF ORAL READING ERRORS[1]

Graphic Similarity Scale
This scale yielded a measure of graphic similarity based on the percentage of letters shared by the response and target word and was coded as follows:

0 - No letters shared
1 - Response contains less than 50% of target word's letters.
2 - Response contains 50% to 74% of target word's letters.
3 - Response contains 75% or more of target word's letters but is missing at least one letter.
4 - Response contains all of the letters of the target but differs in order, or letter(s) are added, or all of the letters are present in the correct order.

Phonic Similarity Scale
This scale was a modification of Pflaum's (1979) scoring procedure. Sound similarity was evaluated in terms of the percentage of sounds shared by the response and target words as follows:

0 - No sounds shared.
1 - Response contains less than 50% of the target word's sounds.
2 - Response contains 50% to 74% of target word's sounds.
3 - Response contains 75% or more of target word's sounds but is missing at least one sound.
4 - Response contains all of the sounds of the target but the order differs or sound(s) were added.

Syntactic Similarity Scale (Burke, 1976)
This scale assessed the grammaticality of an error in terms of its occurrence in a grammatically correct sentence. A nonsense word could be scored highly on this scale if it maintained the grammatic function of the text word. This scale was coded as follows:

0 - Not acceptable.
1 - Acceptable with the preceding context.
2 - Acceptable with the subsequent context.
3 - Acceptable within the sentence but not within the passage.
4 - Acceptable within the total passage.

Semantic Acceptability Scale (Burke, 1976)
This scale judged errors in terms of meaningfulness with similar category definitions as the Syntactic Acceptability Scale:

0 - Not acceptable.
1 - Acceptable with the preceding context.
2 - Acceptable with the subsequent context.
3 - Acceptable within the sentence but not within the passage.
4 - Acceptable within the passage.

Meaning Scale
This scale was used by Goodman and Burke (1972) who referred to it as the "Meaning change" scale. It assessed the child's departure from the author's meaning as follows:

0 - Extensive change in meaning involved.
1 - Minimal change in meaning involved.
2 - No change in meaning involved.

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1. Substitution and letter reversal errors were scored on the five scales.

each error, the converted score on this scale would be 50% (i.e., (40/80)x100=50%).

The reliability of the oral reading analysis was of concern. It has been suggested that oral reading errors may be affected by the difficulty level of the material being read and that the reliability of oral reading analyses may be increased by scoring more than one oral reading sample (Wixson, 1979). Thus, subjects in the present study read two passages orally. The passages were at a similar level of difficulty, i.e. they were read with a word identification error rate of 5% to 11%. To ensure that the two passages read by a subject could be combined to provide more reliable scores, the oral reading scores obtained on the two passages read by a subject were compared. Thus, the reliability of the oral reading analysis across passages was examined to determine the feasibility of combining scores from the two passages read by a subject.

Inter-rater reliability in scoring oral reading errors on the five qualitative scales was also calculated. Five decisions were made regarding the quality of each substitution and letter reversal error. The percentage of agreement by two scorers was calculated for 20 passages on the basis of the number of decision points for a passage. For example, if 21 substitution errors occurred during a passage, there were five decisions for each of 21 errors yielding a total of 105 decision points in scoring the errors qualitatively.

(c) *Edmonton Spelling Ability Test*. The spelling test yielded a grade score. A spelling grade discrepancy score was calculated by subtracting the child's spelling grade level from the grade level expected on the basis of his/her age. More severe spelling difficulties were reflected in larger spelling grade discrepancy scores.

Spelling errors were analyzed qualitatively to assess their phonetic accuracy. The number of misspelled words analyzed qualitatively was equated across subjects by choosing the first ten misspelled words for each child. The words were divided into syllables following the Webster Dictionary syllabication. Spache's (1955) criteria were used to analyze the spelling errors. Each syllable was classified as phonetically accurate (PA) (Spache's categories 1, 3, 4, 7 to 10) or as phonetically inaccurate (PI) (Spache's categories 2, 11, 12, 13). Categories 5 and 6 could be either PA or PI errors. PA errors produced a phonetic equivalent of the target syllable. PI errors produced a syllable which was not recognizable as the target syllable.

Considering only the first ten misspelled words, the number of syllables scored as phonetically accurate was divided by the total number of syllables that contained spelling errors, and multiplied by 100. This percent score reflected the phonetic accuracy of a subject's spelling errors.

II. Nonreading Assessment

Standardized scoring procedures were followed for the psychological and neuropsychological tests. The types of scores used (e.g., scale scores, percents, time scores, error scores) are noted in Appendix B.

Teachers' responses to the Conners Teachers' Questionnaire (Conners, 1969) were scored to yield measures of four dimensions of classroom behaviour: Conduct Problem, Inattentive-passive, Tension-anxiety, and Hyperactivity.

Statistical Analyses

The statistical analyses used in the present study were complex. Thus, the analyses will be discussed in direct relation to the research questions posed below.

Question 1: Can internally valid subgroups of disabled readers be identified on the basis of reading characteristics using objective statistical classification procedures?

Several issues were involved in answering this question. First, which of the many available statistical classification procedures will yield the best results? Advantages and disadvantages are associated with the various statistical classification procedures, and there is little agreement as to the preferred method of analysis. Thus, two statistical procedures were selected to represent diverse approaches to statistical classification. The Q technique of factor analysis is based on vector products as the index of profile similarity. The shape of the profile is important, while level and dispersion are irrelevant in this procedure. Subgroups are defined by considering relationships among a large number of individuals simultaneously. In contrast, Ward's method of cluster analysis is a hierarchical procedure which is based on distance coefficients as the index of similarity. This method is sensitive to differences in the elevation of profiles. In Ward's analysis, a subject cannot move from his/her original cluster. Thus, an iterative relocation procedure was also used in which a subject was relocated in another cluster if s/he was more similar to it than to the original cluster. Q factor analysis and cluster analysis were both used and the preferred classification procedure was decided upon by evaluating the coverage, internal validity and external validity of the classification solutions.

Evaluation of the internal validity of the statistical classification solutions was seen as essential in view of the weaknesses of statistical classfication procedures (Morris et al., 1981). Internal validity may be determined in several ways. In the present study, data manipulation, graphic presentations and statistical measures were used where appropriate.

Data manipulation involved adding variables to an original set of classification variables and repeating the statistical classification procedure. The adequacy of the original subgroups was examined in terms of the stability of the subgroups across the two sets of data.

Graphic measures of internal validity involved visual presentations of the profiles of subgroups plotting mean scores across the classification variables. Visual inspection of profile shape and elevation provided information relevant to the distinctiveness of the subgroups on the classification variables. Where appropriate, graphic plots from discriminant function analyses were examined to evaluate the internal validity of the subgroups.

As confirmation that the subgroups did in fact differ on the variables included in the statistical classification, multivariate and univariate analyses were carried out. A discriminant function analysis was employed where possible, i.e., where the subject:variable ratio was acceptable in view of the recommended ratio of 10:1. The discriminant function analysis yields an overall multivariate test of significance. It also indicates the percent of subjects who can be correctly classified in their respective subgroups by discriminant functions derived from the variables used in the statistical classification. Although subgroup sizes were small, univariate analyses of variance were employed to determine which test variables contributed to the multivariate differences. Where discriminant function analysis was not appropriate, analyses of variance were computed to examine subgroup differences on the classification variables.

Question 2: Do subgoups of disabled readers identified on the basis of reading characteristics have external validity (a) against reading and spelling measures and (b) against nonreading measures?

(a) The first aspect of the external validity of the subgroups was evaluated by employing analyses of variance to examine differences among subgoups on reading and spelling variables external to those used to derive the classifications. These data provided further information for in-depth descriptions of the subgroups.

(b) The second aspect of external validity against nonreading measures is relevant to the interface between reading characteristics and nonreading characteristics of disabled readers. As subgroup sizes were small, univariate analyses of variance were employed. Differences among subgroups on psychological and neuropsychological tests and teachers' ratings of arithmetic achievement and classroom behaviour were examined.

Question 3: Can internally valid subgoups of disabled readers be identified on the basis of nonreading characteristics using objective statistical classification procedures?

Steps similar to those described under the first research question were followed to answer this question. Essentially, Q factor analysis and Ward's cluster analysis were applied to various groups of nonreading measures. The internal validity of the subgroups was evaluated by data manipulation and graphic and statistical tests of the distinctiveness of the subgroups on the variables used in the classification.

The large number of nonreading measures required changes in the statistical procedures described under the first research question. For some analyses, reduced numbers of variables were required. The R technique of factor analysis was employed for the purpose of data reduction. Variables with high loadings on various factors were selected to be used in statistical classification analyses.

Factor scores were used to provide an even smaller group of variables for statistical classification analyses. Factor weights from the R factor analysis were used to calculate factor scores on a reduced number of nonreading test dimensions. The factor scores increased the interpretability of findings by reducing a large number of variables to a few dimensions.

Question 4: Do subgroups of disabled readers identified on the basis of nonreading characteristics have external validity (a) against nonreading measures, and (b) against reading and spelling measures?

(a) Evaluation of the first aspect of the external validity of the subgroups involved analyses of variance. The nonreading subgroups were compared on the extensive battery of nonreading measures which were external to the classification variables.

(b) The question of external validity against reading and spelling measures has relevance to the interface between reading and nonreading characteristics of disabled readers. Univariate analyses of variance were used. Differences among subgroups on reading and spelling measures were examined.

Question 5: Are there systematic relationships between reading characteristics and nonreading characteristics of disabled readers?

One approach to answering this question involved the relationship between subgroups of disabled readers based on reading characteristics and subgroups based on nonreading characteristics. Subgroup membership was compared across the two sets of data to see if the same subjects were grouped together by statistical classification of each type of data. This was a stringent test of the question. It required that the pattern of differences on one set of data be directly related to the pattern of differences on the other set of data.

A less stringent approach to the question of the interface between reading characteristics and nonreading characteristics was addressed under Questions 2 and 4 which involved the external validity of the subgroups. Specifically, do reading subgroups have external validity when evaluated against nonreading performance characteristics? Are nonreading subgroups distinct in terms of reading characteristics?

Supplementary Analyses: Additional analyses were related to the reliability of measures used and to the characteristics of the sample of disabled readers in the present study. Sample heterogeneity, the relationships among reading and spelling measures, and the relationships among nonreading measures in this sample were of interest.

Multivariate and univariate analyses of variance were computed comparing 9- and 10-year-olds and comparing boys and girls. The purpose was to determine if test performance differences associated with age or sex contraindicated analyses collapsing across age and sex.

The reliability of the oral reading analysis was assessed. To ensure that the two passages read orally by each subject could be combined to provide more reliable scores, possible differences in oral reading scores obtained on the two passages read by a subject were investigated. The scores on the two passages were compared in multivariate Hotellings T^2 analyses for dependent samples.

The reading and spelling characteristics and nonreading characteristics of the disabled readers were examined by evaluating average performance levels and variability in scores for the total sample. Relationships among reading and spelling measures and among nonreading measures were examined in correlational analyses and R factor analyses.

Limitations of the Present Study

The present study was limited by factors outlined below.

1. Subject selection criteria contributed to limitations of the present study.
    - a. The limited age span increased homogeneity while at the same time limiting the generalizability of the results.
    - b. The exclusion of children reading below the primary level, i.e., nonreaders, is recognized as a limitation. However, such children were beyond the scope of the present study which included an analysis of oral reading errors. Subjects were required to have some reading skill so that oral reading samples could be obtained.
    - c. It is recognized that it is important to attempt to minimize the influence of background factors in the study. An attempt was made to keep a balance in terms of background factors by selecting subjects from a large number of schools spread throughout a large urban area. It is recognized that this does not represent rigorous control and is a limitation of the study.
2. The size of the sample contributed to limitations of the present study.
    - a. Data manipulation in the form of split-half procedures to assess the internal validity of the

subgroups identified was not possible.

   b. The sample size also had limitations in that subgroup sizes were small and decreased the sensitivity of statistical tests of differences among the subgroups.
   c. The stability of statistical procedures was weakened by the small sample size.

3. Limitations were associated with the oral reading analysis.
   a. Passages read at a word recognition error rate of 6% to 11% were chosen for analysis. Comprehension of the passages was not a criterion for determining the passages to be scored. The error rate chosen does not adhere strictly to criteria for defining instructional or frustration functional reading levels. The error rate conforms most closely to frustration level. Passages at this level of difficulty were selected because they provided a sufficient number of oral reading errors for analysis and yet were not so difficult that the children were unable to use various strategies in reading them. Instructional level passages and changes in strategies from instructional to frustration level would be of interest but were beyond the scope of the present study.
   b. The reliability of the qualitative analyses of the oral reading passages may be an issue. The

procedures included to ensure reliability have been described.

4. No information was obtained regarding teaching strategies and the type of curriculum to which the subjects were exposed in the classroom and in the resource room. It is possible that the reading strategies being taught at the time of testing may have influenced the strategies used by the subjects during oral reading.
5. Individual differences in emotional and/or behavioural factors may contribute to the identification of homogeneous subgroups of disabled readers. Such factors may be evaluated using questionnaires completed by teachers. A limited measure of behavioural factors was included in the present study. It is recognized that such factors may be important and their brief consideration is a limitation of the present study.
6. The inclusion of a normal comparison group would have broadened the scope of the study. Statements could have been made about differences between normal readers and disabled readers in terms of reading and spelling characteristics, nonreading characteristics and the relationships among these measures. If normal readers had also been assessed, the uniqueness of the subgroups to disabled readers could have been evaluated. However, extensive testing time was required and the assessment of a normal group was beyond the scope of the present

study.

VI. Results of the Analyses of Reading and Spelling Measures

The results of the analyses of reading and spelling measures are presented in this chapter. The results of the analyses of nonreading measures will be presented in the next chapter. Relationships between reading and nonreading measures will be presented in these two chapters where appropriate.

The reading and spelling measures included: *Woodcock Reading Mastery Tests* assessing word identification, word attack and passage comprehension; oral reading samples scored for comprehension, speed, self-corrections, repetitions and error types, and qualitative analyses of Graphic similarity, Phonic similarity, Syntactic acceptability, Semantic acceptability and Meaning; and spelling achievement assessed by the *Edmonton Spelling Ability Test* scored to yield a spelling grade level, the percent of phonetically accurate spelling errors and a spelling grade discrepancy score.

Analyses presented in this chapter address the following: the reliability of the oral reading analysis; the homogeneity of the sample in terms of age and sex; the reading and spelling characteristics of the total sample; the relationships among these measures within the sample; and finally, the identification of subgroups based on the statistical classification of reading measures.

Two approaches to statistical classification were used and their coverage and internal validity were compared to decide upon the preferred statistical classificaiton procedure. External validity and the interface between reading and nonreading characteristics of the subgroups were then considered. The two approaches to statistical classification were selected because they employed different indices of similarity in the search for homogeneous subgroups. One technique, Q factor analyis, is sensitive to differences in the shape of the profiles. The other technique, Ward's method of cluster analysis, is sensitive to differences in the level or elevation of profiles. A second cluster analytic technique of relocation was selected to follow the Ward's analysis as recommended by Wishart (1978).

A. Reliability of the Oral Reading Analysis

Two types of reliability were investigated. First, the reliability of the oral reading analysis scores across passages was of interest to determine the feasibility of combining scores from the two passages read by a subject. Second, inter-rater reliability in scoring oral reading errors on the five qualitative scales was determined.

Reliability of Scores across Passages

Subjects in the present study read two passages orally. For each subject, the passage read with the fewest errors was designated Passage A and the more difficult passage, Passage B. Oral reading scores on Passages A and B were compared to investigate possible differences associated with passage difficulty within the range of difficulty selected for study, i.e. an error rate of 5% to 11%.

The results of three multivariate Hotellings T^2 analyses for dependent samples comparing Passages A and B are presented in Table VI.1 (DERS PROGRAM MULV06, Division of Educational Research Services, University of Alberta, 1977). The univariate tests for the variables in each analysis are listed, together with the multivariate test results. The only significant difference between passages was in error rate. Although the two passages read by individual subjects differed in difficulty level, there were no differences across passages in speed, comprehension, types of errors or qualitative analyses of errors. Oral reading scores were thus found to be reliable across the two passages and the passages were combined for further analyses by taking the average of the scores on the two passages.

Inter-rater Reliability in Scoring Oral Reading Errors Qualitatively

Inter-rater reliability in scoring substitution and letter order reversal errors on the five qualitative scales was calculated. The 98 passages read by the total sample of 49 subjects were scored by the Experimenter. Ten subjects were selected randomly and the twenty passages read by these ten subjects were scored independently by a second person. The percent of agreement between the two scorers in scoring

TABLE VI.1
RESULTS OF THREE MULTIVARIATE HOTELLINGS T^2 ANALYSES FOR DEPENDENT SAMPLES EVALUATING DIFFERENCES BETWEEN ORAL READING PASSAGES A AND B

MEASURES	UNIVARIATE HOTELLINGS T^2	MULTIVARIATE HOTELLINGS T^2
Error Rate[1]	91.34**	102.097**
Speed Of Oral Reading	2.85	(df=8,41)
Oral Reading Comprehension	0.29	
Self-corrections	1.50	
Repetitions	0.14	
Insertions	0.01	
Omissions	0.00	
Word Order Reversals	1.36	
Letter Order Reversals[2]	0.57	2.776
Substitutions:		(df=5,44)
Stem	0.08	
Affix	0.03	
Other Meaningful	0.28	
Nonsense	1.63	
Graphic Similarity[3]	0.75	7.39
Phonic Similarity	0.22	(df=5,44)
Syntactic Acceptability	0.29	
Semantic Acceptability	1.74	
Meaning	2.33	

** $p < .01$

1. Degrees Of Freedom = 2,41 For The Univariate Analyses.
2. Degrees Of Freedom = 2,44 For The Univariate Analyses.
3. Degrees Of Freedom = 2,44 For The Univariate Analyses.

errors on the five qualitative scales ranged from 85% to 97% per passage, with an average agreement of 91.5% across the twenty passages.

B. Age and Sex Characteristics of the Total Sample in Relation to Reading and Spelling Measures

Prior to further analyses involving the total sample of disabled readers, the factors of age and sex were examined to determine their contribution to the heterogeneity of the sample and the feasibility of collapsing across age and sex in the search for homogeneous subgroups of disabled readers. The possibility that sex differences might contribute to sample heterogeneity was of particular interest as the ratio of boys to girls in the present study was approximately 2:1, whereas the majority of studies of disabled readers restrict samples to boys only.

The 24 9-year-olds were compared with the 25 10-year-olds and the 33 boys were compared with the 16 girls in multivariate and univariate analyses of variance using the MANOVA program of the *Statistical Package for the Social Sciences* (SPSS) (Hull & Nie, 1981). The results of these analyses are presented in Table VI.2. Univariate tests for the variables in the analyses are presented along with the multivariate tests.

Age comparisons yielded significant differences in spelling with 10-year-old children achieving higher spelling grade scores but scoring further below the grade score .

TABLE VI.2
AGE AND SEX COMPARISONS ACROSS READING AND SPELLING MEASURES

MEASURES	AGE COMPARISONS		SEX COMPARISONS	
	Uni-variate *F*-ratio[1]	Multi-variate *F*-ratio	Uni-variate *F*-ratio[1]	Multi-variate *F*-ratio
Word Identification	.125	15.099** (df=6,42)	3.950	1.40 (df=6,42)
Word Attack	1.802		.068	
Passage Comprehension	1.484		.473	
Spelling Grade	4.668*		.392	
Spelling Grade Discrepancy	8.042**		.878	
Phonetic Accuracy in Spelling	3.068		.235	
Graphic Similarity	.006	0.315 (df=5,43)	1.0467	0.416 (df=5,43)
Phonic Similarity	.319		1.039	
Syntactic Accuracy	.215		.368	
Semantic Accuracy	.143		1.203	
Meaning	.156		.283	
Error Rate	.003	0.992 (df=10,38)	.728	1.043 (df=10,38)
Speed	.252		.720	
Oral Passage Comprehension	.007		.117	
Self-Correction	.474		.805	
Letter Order Reversal	1.436		.841	
Substitutions:				
Stem	2.818		.761	
Affix	1.449		.378	
Other Meaninful	2.711		.091	
Nonsense	.006		.452	
Repetitions	.115		.696	

* *p* < .05

** *p* < .01

1. Degrees of freedom = 1,47 for all univariate analyses.

expected for their age compared with 9-year-old children. There were no significant age differences on the reading measures. Thus, homogeneity in terms of age was indicated for the present sample for reading measures and the 9- and 10-year-olds were combined for further analyses.

Comparisons of boys and girls indicated that there were no significant sex differences on the reading and spelling measures. Since sex did not affect performance on these measures, boys and girls were combined for further analyses.

C. Reading Characteristics of the Total Sample

Standardized Reading Test Performance

As described earlier, achievement indices on the *Woodcock Reading Mastery Tests* were adjusted such that higher scores reflect higher reading achievement. A score of 100 indicates achievement at age expected grade level. The mean achievement scores for the total sample on the three aspects of reading assessed by the *Woodcock* tests, namely, Word Identification, Word Attack and Passage Comprehension, were 69.2, 81.9, and 83.6, respectively.

The *Woodcock* grades achievement indices to indicate whether the level of reading difficulty is mild, moderate or severe. Based on the *Woodcock* criteria, the adjusted achievement indices used in the present study reflect three levels of reading difficulty: severe difficulty (index of 70 or less); moderate difficulty (index of 71 to 75); and mild difficulty (index of 76 to 99). The numbers of subjects achieving scores within the mild, moderate and severe difficulty ranges on the three *Woodcock* tests are presented in Table VI.3. More subjects encountered moderate to severe difficulties on the Word Identification test than on the Word Attack and Passage Comprehension tests.

Oral Reading Characteristics

Samples of oral reading of connected text were scored to provide information about the reader's use of contextual cues as well as graphic and phonic cues in identifying words and deriving meaning from written text. In the present study, when the difficulty level of the oral reading passages was equated across subjects, the passages ranged in readability level from pre-primer to late grade 4. One pre-primer passage, eight primer, nine grade one, 27 grade two, 25 grade three, 11 early grade four and 17 late grade four level passages were read by the 49 subjects.

Each subject read two passages orally. The passage with the lowest error rate was designated Passage A, for which the average error rate was 7.6% across the 49 subjects. The passage with the higher error rate was designated Passage B for which the average error rate was 9.2% across all subjects. Subjects read Passage A at an average speed of 69.5 words per minute, and Passage B at 67 words per minute. Comprehension of the two passages was comparable at 61.6% and 59.6%, respectively.

TABLE VI.3
NUMBERS OF SUBJECTS SCORING WITHIN THE MILD, MODERATE AND SEVERE DIFFICULTY RANGES ON THE WOODCOCK READING MASTERY TESTS

ACHIEVEMENT INDEX	WOODCOCK TESTS		
	Word Ident.	Word Attack	Passage Comprehen.
76 to 79 (Mild Difficulty)	18	47	43
71 to 75 (Moderate Difficulty)	11	1	3
≤ 70 (Severe Difficulty)	20	1	3

The types of oral reading errors characteristic of the sample of disabled readers were examined combining the scores on the two passages read by each subject. The mean percentage of errors occurring in each error category for the total sample indicated that word order and letter order reversals were negligible (1% and 2%, respectively). Insertions and omissions were relatively infrequent (6% and 11%, respectively). Substitution errors were most common. Meaningful substitutions (54%) were most frequent, followed by substitutions which had the same stem as the target word (11%). Nonsense word substitutions (9%) and substitutions involving the same affix as the target word (6%) were less frequent. On the average, 24% of errors were spontaneously self-corrected.

Substitution and letter reversal errors were analyzed qualitatively. The average scores on the five qualitative scales indicated that Graphic similarity and Syntactic acceptability were highest (56% and 57%, respectively). Phonic similarity and Semantic acceptability were lower (44% and 43%, respectively). The tendency to make errors which changed the meaning of the passage was high for the sample as indicated by the low mean score on the Meaning scale (30%). Thus, the disabled readers in the present sample relied most heavily on graphic and syntactic cues in reading connected text. Sound, or phonic, cues and semantic cues were of less importance and errors tended to change the meaning of the passage.

D. Spelling Characteristics of the Total Sample

Spelling Achievement

The disabled readers experienced difficulty in spelling, scoring from five months to three years below expected grade level on the *Edmonton Spelling Ability Test* with an average discrepancy of 1.8 years (SD=0.64). Spelling achievement ranged from the grade 2 to grade 4 level (Mean=3.2, SD=0.64).

Phonetic Accuracy of Spelling Errors

The mean percent of phonetically accurate spelling errors was 50% for the total sample (SD= 19.9). However, phonetic accuracy varied widely ranging from 7% to 92% of the spelling errors of individual subjects. Nineteen subjects were considered to be "PA" spellers (phonetically accurate) with at least 60% of their spelling errors classified as phonetically accurate. Thirty subjects who had fewer than 60% of spelling errors classified as phonetically accurate were considered to be "PI" spellers (phonetically inaccurate).

Reading characteristics of the PA and PI spellers were compared to investigate the relationship between phonetic accuracy in spelling and reading characteristics. A multivariate analysis of variance which included oral reading error types and qualitative scales did not reach significance (Hotellings T^2=.401, df=10,38, $p>.05$) (SPSS

MANOVA, Hull & Nie, 1981). Although PA spellers tended to have higher spelling achievement and higher scores on the Word Attack test, a multivariate analysis of variance which included spelling scores, *Woodcock* tests, and oral reading measures of error rate, speed, comprehension and self-corrections was not significant (Hotellings T^2=.147, df=10,38, p>.05).

E. Correlations among Reading and Spelling Measures

Correlations among reading and spelling measures were examined to determine the relationships among the skills assessed. Three types of relationships were of particular interest. First, relationships among the various aspects of reading assessed were examined to determine the extent to which component skills had been tested. Second, relationships among oral reading measures were examined to estimate the sensitivity of the measures to differences in reading strategies. Third, relationships between reading and spelling measures were examined to evaluate the interdependence of reading and spelling skills.

The correlations among measures of the reading and spelling battery are presented in Table VI.4. Fifty-nine of the 171 correlations were .30 and higher and 29 were .40 and higher. Correlations of .40 and higher are underlined in Table VI.4 and will be discussed as they indicate that the two tests share 16% of common variability.

TABLE VI.4
CORRELATIONS AMONG READING AND SPELLING MEASURES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1 Word Ident.																			
2 Word Attack	42																		
3 Passage Compreh.	65	23																	
4 Spell. Grade	50	44	43																
5 Phon.Acc.(Spell.)	-00	47	-12	17															
6 Graphic Sim.	18	31	03	26	15														
7 Phonic Sim.	28	34	12	35	21	75													
8 Syntactic Accept.	30	24	39	31	07	-07	09												
9 Semantic Accept.	-24	-39	-07	-16	-19	-47	-40	42											
10 Meaning	02	-38	07	-02	-17	-55	-32	31	78										
11 Speed (w.p.m.)	46	-01	43	37	-23	13	13	24	02	10									
12 Oral Pass.Compr.	-28	-25	-06	-34	-07	-42	-41	-17	24	16	-27								
13 Self-corr.	-28	02	-21	-03	16	-08	-25	-33	07	-09	-42	41							
14 Letter Reversal	-38	-16	-38	-29	-09	15	-32	-42	00	-13	-15	15	28						
15 Same Stem	14	-07	-02	06	05	21	38	-05	09	29	07	-20	-09	-01					
16 Same Affix	30	11	16	17	-03	09	38	27	-19	-04	11	28	-15	-38	-00				
17 Other Meaningful	-51	-29	-27	-33	09	-32	-52	-20	24	-01	-32	-40	33	22	-35	-35			
18 Nonsense	34	55	25	33	23	59	61	24	-58	-50	19	02	-25	-17	-06	36	-45		
19 Repetitions	-04	-05	02	07	-07	-01	28	-04	-09	-28	-05	-08	35	-01	-42	01	11	06	

1. Decimal points are omitted.

Although subjects were selected primarily on the basis of a single aspect of reading performance, i.e. difficulty in word identification, the correlations indicated that word identification was highly related to other aspects of reading performance, namely, Passage Comprehension and Word Attack as measured by *Woodcock* tests, and speed of oral reading.

The relationship between word identification and comprehension skills was not confirmed by comprehension of the passages read orally. The lack of relationship may be a function of differences in the readability level of the passages read orally by subjects who differed in word identification skill. Children who scored lower on the Word Identification test reached the criterion error rate on passages of lower readability levels than children with higher Word Identification scores: 81% of passages read by children with a Word Identification achievement index of -30 or less were at the Preprimer to Grade 2 level whereas only 23% of stories read by children with higher Word Identification scores were at these levels. Comprehension of the easier passages read by children with lower Word Identification scores could be expected to be higher than comprehension of the more difficult passages read by children with higher Word Identification scores.

Several relationships were noted among scores of the oral reading analysis. The Graphic and Phonic similarity scales were highly correlated. This finding may reflect the high degree of correspondence between letters and sounds in an alphabetic writing system. Thus, children who were attentive to grapho-phonic relationships obtained high scores on both the Graphic and Phonic similarity scales. It may not be practical, therefore, to attempt to separate the use of these two types of cues in an alphabetic writing system.

The Graphic and Phonic similarity scales were negatively correlated with the Semantic acceptability and Meaning scales, oral reading passage comprehension and frequency of meaningful substitution errors. Thus, high reliance on grapho-phonic cues tended to be associated with low attendance to the meaning of material being read and with decreased comprehension. High positive correlations between the Graphic and Phonic similarity scales and the frequency of nonsense substitution errors further support the conclusion that high reliance on grapho-phonic cues was related to reading as a decoding task with little consideration for the meaning of what was being read. This interpretation was also supported by a high positive correlation between Semantic acceptability and the Meaning scale, both of which were negatively correlated with nonsense word substitutions.

Speed of oral reading and the frequency of self-corrections were negatively correlated. Children who tended to self-correct took longer to read passages because they went back to repeat words and phrases. However, children who made frequent self-corrections tended to have higher comprehension of the passage. Self-correction involves monitoring errors in relation to the context of the passage and is thus related to comprehension.

Relationships among qualitative reading scales indicated independence of strategies used in oral reading of connected text. High Graphic and Phonic similarity of substitution errors were associated with decreased passage comprehension and thus with reading as a decoding and meaningless task. A separation between decoding and reading for meaning was suggested by the correlations among qualitative measures of oral reading. In contrast, interdependence among reading skills measured by *Woodcock* tests was indicated by the correlations among these reading measures.

Spelling achievement was found to be closely related to reading achievement as indicated by high positive correlations between spelling grade and scores on the three *Woodcock* reading tests. A high positive correlation between phonetically accurate spelling errors and *Woodcock* Word Attack suggests that children who show facility in reading nonsense words have some grasp of spelling to sound correspondence rules which they also attempt to apply in sound to spelling tasks. These correlations point to a systematic relationship between aspects of reading and spelling performance.

F. R Factor Analysis of Reading Measures

The five qualitative reading scales were chosen to assess the types of information being used to read passages orally, i.e. graphic, phonic, syntactic, semantic and meaning cues. An R technique of factor analysis (principal components with varimax rotation) was applied to these scales to determine the dimensions assessed (DERS PROGRAM FACT20 Factor Analysis Package, 1980). Two factors had eigenvalues of 1.0 or higher and indicated that the five scales reflected the use of two sources of information available in the oral reading of passages, namely, contextual information and grapho-phonic information. Factor loadings are presented in Table VI.5. A grapho-phonic cue use factor was characterized by high loadings on the Graphic and Phonic similarity scales. A contextual cue use factor was characterized by high positive loadings on the Syntactic and Semantic acceptability scales and the Meaning scale.

The five qualitative scales were included in a second factor analysis together with the *Woodcock* tests, and oral reading measures of speed, passage comprehension and self-corrections to obtain information about the relationships among grapho-phonic cue use, contextual cue use and other aspects of reading. A principal components analysis with varimax rotation yielded four factors with eigenvalues of 1.0 or higher. The factor loadings for each measure are presented in Table VI.6.

TABLE VI.5
SUMMARY OF THE RESULTS OF AN R FACTOR ANALYSIS OF FIVE QUALITATIVE ORAL READING SCALES[1]

SCALES	FACTORS	
	1	2
Graphic Similarity Scale	89	-22
Phonic Similarity Scale	92	01
Syntactic Acceptability Scale	23	83
Semantic Acceptability Scale	-45	79
Meaning Scale	-48	73
Percent Of Total Variance	42.32	37.96

1. Factor loadings are given for each scale; decimal points are omitted.

TABLE VI.6
SUMMARY OF THE RESULTS OF AN R FACTOR ANALYSIS OF ELEVEN READING MEASURES[1]

MEASURES	FACTORS			
	1	2	3	4
Woodcock Reading Mastery Tests				
Word Identification	16	83	-04	26
Word Attack	21	25	-17	81
Passage Comprehension	-06	86	07	20
Oral Reading Analysis				
Graphic Similarity	70	-03	-43	25
Phonic Similarity	76	06	-22	29
Syntactic Acceptability	25	34	73	35
Semantic Acceptability	-23	-16	88	-17
Meaning	-23	07	81	-28
Speed	27	71	05	-38
Passage Compreh.	-78	-14	01	02
Self-Corrections	-58	-39	-19	38
Percent Of Total Variance	21.15	20.98	20.58	12.88

---

[1] Factor loadings are given for each test; decimal points are omitted.

The first factor was characterized by high positive loadings on the Graphic and Phonic similarity scales and high negative loadings for oral reading passage comprehension and self-corrections. This factor may thus be described as a grapho-phonic cue use factor. The second factor had high loadings for Word Identification and Passage Comprehension tests together with speed of oral reading and was considered to reflect reading proficiency. The third factor reflected contextual cue use with high positive loadings on the Syntactic and Semantic acceptability scales and the Meaning scale. A fourth factor was related to word attack skills with a high loading on the Word Attack test.

The high negative loadings for oral reading passage comprehension and self-corrections on the same factor as the high positive Graphic and Phonic similarity scale loadings suggested that children who relied heavily on the grapho-phonic cues had lower comprehension of the passage and made fewer self-corrections. This finding reinforces an interpretation of high grapho-phonic cue use involving decoding on the basis of grapho-phonic information associated with little attention to the meaning of the material being read.

G. Identification of Subgroups by Q Factor Analysis of Reading Measures

The central problem addressed in the present study involves the interface between reading and nonreading characteristics of subgroups of disabled readers. Before this problem is addressed, it is important to determine if internally valid subgroups of disabled readers can be identified on the basis of reading characteristics using objective statistical classification procedures. Q factor analysis was applied to eleven reading scores which included the three *Woodcock* tests of Word Identification, Word Attack and Passage Comprehension; the five qualitative oral reading scales of Graphic similarity, Phonic similarity, Syntactic acceptability, Semantic acceptability and Meaning; oral reading speed, comprehension and self-corrections. Scores on the eleven variables were transformed to standardized z-scores based on the performance of the total sample of 49 disabled readers.

For the Q factor analysis, the matrix of z-scores was transposed so that the test variables were along the Y-axis and the 49 subjects were along the X-axis. The transposed matrix was submitted to a principal components analysis with varimax rotation (DERS PROGRAM FACT20, 1980). Several solutions of the Q factor analysis were considered: first, the nine factors with eigenvalues of 1.0 or higher; second, the three, four and five factor solutions were compared following the procedure used by Doehring et al. (1981); and third, a single solution was selected on the basis of a scree test (Cattell, 1966) and stability across the three, four and five factor solutions.

The results of the various solutions are summarized in Table VI.7. Positive factor loadings of .40 and higher define subgroup membership. Subjects with high positive loadings on more than one factor were assigned to the subgroup defined by the factor on which they had the highest loading. As can be seen from Table VI.7, a large number of subjects could not be classified by the Q factor analysis. Double positive loadings and high negative loadings were frequent for all solutions.

Subjects loading highly on the first three factors of the three, four and five factor solutions of the Q factor analysis were compared. The first two factors were stable across the three solutions with ten subjects loading highly on the first factor and eight subjects loading highly on the second factor. Eleven of fifteen subjects loaded highly on the third and fourth factors of both the four and five factor solutions.

The four factor solution was selected for further evaluation as it appeared to have stability in comparisons of the three, four and five factor solutions and its examination was indicated by a scree test (Cattell, 1966). The factor loadings of the subjects classified in the four subgroups are included in Appendix E. The problem of double factor loadings was evident in the four factor solution. If a mixed subgroup was represented by the double positive loadings of 10 subjects, then the mixed subgroup was quite heterogeneous. Three of these subjects had high loadings on

TABLE VI.7
SUMMARY OF THE RESULTS OF THE Q FACTOR ANALYSIS OF ELEVEN READING VARIABLES

	FACTOR SOLUTION			
	9	5	4	3
% Total Variance Accounted For ·	98	83	76	64
% Classified'	65	63	67	55
% Double Loadings'	20	22	20	6
% Negative Loadings'	55	45	49	45

1. Positive factor loadings ≥ .40 defined classification.

2. Double loadings refer to positive loadings ≥ .40.
   on more than one factor.

3. Negative loadings refer to factor loadings ≤ -.40.

Factors 1 and 2, three on Factors 3 and 4, two on Factors 1 and 3, and two on Factors 2 and 4.

Internal Validity of the Q Factor Analysis Subgroups

Internal validity of the Q factor analysis solution based on 11 reading measures was examined in several ways. Data manipulation, graphic presentations and statistical approaches were used.

One approach to the internal validation of subgroups involves data manipulation in which variables are added to the original set of classification variables and the statistical classification procedure is repeated. The subgroups resulting from the two analyses are compared. If the subgroups of the first analysis are reproduced even when variables have been added, then the reliability or stability of the original subgroups is confirmed.

Two spelling measures, i.e. spelling grade discrepancy score and the percent of phonetically accurate spelling errors, were added to the 11 reading variables of the first analysis. Reading variables were also added, including a word identification grade discrepancy score indicating the severity of the reading difficulty, and the percent of repetitions and of five types of oral reading errors: letter order reversals and substitutions of same stem, same affix, other meaningful word or nonsense word. Thus, a total of 20 reading and spelling z-scores were included in a second Q factor analysis to assess the reliability of the subgroups previously formed on the basis of 11 of these 20 variables.

The results of various factor solutions for the Q factor analysis of 20 reading and spelling z-scores are presented in Table VI.8. Eleven factors had eigenvalues of 1.0 or greater. On the basis of a scree test, the eight factor solution was selected for examination. The three, four and five factor solutions were also examined. The first three factors of these three solutions were similar, with 16 subjects loading highly on the same factor across the three solutions. Twenty-five subjects loaded highly on the same factors across two solutions. However, only 28 subjects (57%) were classified.

To evaluate the internal validity of the subgroups identified by the Q factor analysis of 11 reading measures, the subgroups were compared with those derived from the Q factor analysis of 20 reading and spelling variables. The four factor solutions of the two sets of variables placed 19 subjects in similar subgroups and agreed on 13 subjects to be left unclassified, yielding 65% agreement overall, but only 39% agreement for classified subjects. In view of the large number of unclassified subjects contributing to agreement across the analyses, the reliability of the subgroups assessed by the addition of variables was considered to be low for the Q factor analysis.

Internal validity of subgroups may be examined using graphic presentations which allow visual inspection of profiles. Profiles of the four subgroups identified by the

TABLE VI.8
SUMMARY OF THE RESULTS OF THE Q FACTOR ANALYSIS OF TWENTY READING AND SPELLING MEASURES

	FACTOR		SOLUTION		
	11	8	5	4	3
% Total Variance Accounted For	92	82	65	57	49
% Classified[1]	65	69	59	55	57
% Double Loadings[2]	14	16	8	10	6
% Negative Loadings[3]	43	51	51	53	51

1. Positive factor loadings ≥ .40 defined classification.

2. Double loadings refer to positive loadings ≥ .40. on more than one factor.

3. Negative loadings refer to factor loadings ≤ -.40.

Q factor analysis of 11 reading measures are presented in Figure VI.1. Mean z-scores are plotted for each subgroup across the 11 classification variables. The factor score profiles representing the ideal profiles were not obtained. The linear dependence among reading measures did not permit the calculation of factor scores by the factor analysis program (DERS PROGRAM FACT23 Factor Score Estimates, 1981). The profiles presented in Figure VI.1 are thus composites of the profiles of the individuals comprising each subgroup. As can be seen from the figure, the shapes of the profiles are distinctive.

Subgroup 1, comprised of eight boys and two girls, had low performance on the *Woodcock* tests and read oral passages of lower readability than those read by the other subgroups. Despite the low readability of the passages, oral reading was very slow. Relatively high scores on the Semantic acceptability and Meaning scales, and in oral reading passage comprehension indicated that context was more important to word identification than were grapho-phonic cues for this subgroup. Self-corrections were also high suggesting attention to meaning. Subgroup 1 was thus characterized by striving for meaning but poorly developed component reading skills, such as word attack skills, for automatic word recognition. This subgroup appeared to be composed of the *least proficient readers*.

Subgroup 2 was comprised of five boys and three girls and had among the highest scores on the *Woodcock* tests. This

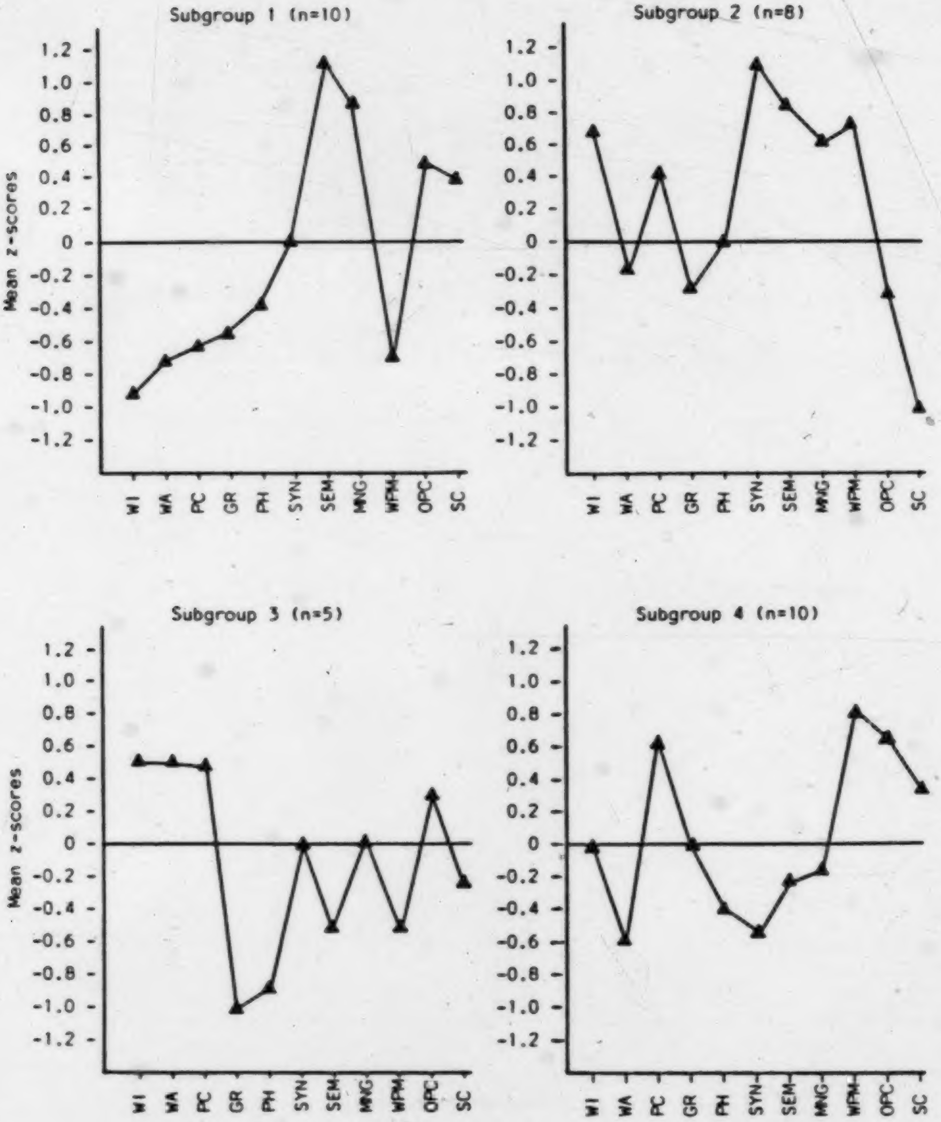


Figure VI.1. Mean z-score profiles across the classification variables for four subgroups formed by Q factor analysis of eleven reading measures.

KEY

WI - Word Identification
WA - Word Attack
PC - Passage Comprehension
GR - Graphic similarity
PH - Phonic similarity
SYN-Syntactic acceptability
SEM - Semantic acceptability
MNG - Meaning scale
WPM - Speed of oral reading
OPC - Oral passage comprehension
SC - Self-corrections

subgroup read passages of relatively high readability at a fast rate. High scores on the Syntactic acceptability, Semantic acceptability and Meaning scales suggested that contextual cues contributed to word identification. Grapho-phonic cues were also used as indicated by average scores on the Graphic and Phonic similarity scales. Relative speed in word identification, however, was found in conjunction with few self-corrections and low oral passage comprehension. This pattern suggests that Subgroup 2 had developed component word identification skills, particularly the use of simple contextual cues, to a relatively automatic level but failed to monitor for comprehension (*context cue users, poor comprehenders*).

Subgroup 3 was a small subgroup comprised of four boys and one girl. This subgroup had slow oral reading and low scores on scales reflecting the use of grapho-phonic cues in oral reading. In contrast, *Woodcock* scores and oral reading passage comprehension were relatively high. This subgroup appeared to have greater skill than the other subgroups in applying spelling-sound correspondence rules when reading words in isolation. However, these skills did not appear to be applied efficiently during oral reading. Contextual cues appeared to be preferred over grapho-phonic cues during oral reading and although reading was slow, comprehension was relatively good. *Slow oral reading* and *low use of grapho-phonic cues* were the outstanding characteristics of Subgroup 3.

Six boys and four girls comprised Subgroup 4 which had relatively high comprehension, self-corrections and fast oral reading speed, in contrast to poor Word Attack and low Phonic similarity and Syntactic acceptability of oral reading errors. *High comprehension* and *fast oral reading* in contrast to *poor word attack* thus characterized Subgroup 4.

Statistical approaches to internal validation of subgroups include discriminant function analysis and analysis of variance. Discriminant function analysis requires a large number of subjects in relation to the number of variables, i.e., a ratio of 10:1 for a conservative analysis and was not appropriate to evaluate the 33 subjects classified in four subgroups on the basis of 11 reading measures.

In view of the small sizes of the subgroups, analyses of variance computed on the classification variable test scores were considered conservative tests of the distinctiveness of the subgroups. Means, standard deviations, F-ratios and the results of Scheffe's multiple comparisons of the four subgroups are presented in Appendix F.

The analyses of variance confirmed the distinctiveness of the subgroups on the classification variables. Only differences on the Graphic similarity and Phonic similarity scales did not reach significance. Scheffe comparisons indicated that the majority of subgroup differences involved Subgroup 1. Subgroup 1 (least proficient) differed from

Subgroup 2 (context cue users, poor comprehenders) on measures of Word Identification, Passage Comprehension, the Syntactic acceptability scale, speed of oral reading and self-corrections. Subgroup 1 differed from Subgroup 3 (poor grapho-phonic cue users) on measures of Word Identification, Word Attack, Passage Comprehension, and Semantic acceptability, and differed from Subgroup 4 (high comprehenders) in Passage Comprehension, Semantic acceptability, the Meaning scale and speed of oral reading. Subgroup 2 (context cue users, poor comprehenders) differed from both Subgroups 3 (low grapho-phonic cue users) and 4 (high comprehenders) in Semantic acceptabilty, and from Subgroup 3 in speed of oral reading, and from Subgroup 4 in oral reading passage comprehension and self-corrections. Word Attack and oral reading speed distinguished Subgroups 3 and 4.

External Validity of the Q Factor Analysis Subgroups Against Reading and Spelling Measures

The four subgroups formed by the Q factor analysis of 11 reading measures were evaluated against reading and spelling measures external to the classification. The four subgroups were compared in analyses of variance of the following measures: oral reading error types, spelling grade, spelling grade discrepancy, and the percent of phonetically accurate spelling errors. Means, standard deviations and _F_-ratios for these analyses are presented in

Appendix G. Significant differences were found for word order reversals, spelling grade and spelling grade discrepancy scores. Post hoc comparisons indicated that the poor performance of Subgroup 1, the least proficient readers, contributed most to these differences.

External Validity of the Q Factor Analysis Subgroups Against Nonreading Measures

An important aspect of the external validation of the subgroups involved comparisons on nonreading measures. Analyses of variance were computed comparing the four subgroups on nonreading measures of IQ, language, memory, sequencing, perception, visual-motor functioning and motor functioning, and behaviour ratings. Means, standard deviations and F-ratios for the comparisons are presented in Appendix H. Only four comparisons reached significance. Scheffe multiple comparisons indicated that Subgroup 1 (least proficient) was significantly below Subgroup 2 (context cue users, poor comprehenders) and Subgroup 4 (high comprehenders) on Coding; Subgroup 3 (low grapho-phonic cue users) was significantly below Subgroup 1 (least proficient) and Subgroup 2 (context cue users, poor comprehenders) on *BVRT* copying; and Subgroup 4 (high comprehenders) had higher levels on teachers' ratings of Tension and Anxiety than Subgroup 2 (context cue users, poor comprehenders) and Subgroup 3 (low grapho-phonic cue users). Scheffe's test was not significant for *PPVT-R* where Subgroup 4 (high comprehenders) tended to have the best performance.

In comparison with nonreading test norms, the average performance levels of the four subgroups indicated that all four subgroups experienced difficulty in the rapid recall of automatic sequences (Word Series), rapid naming (Confrontation Naming) and finger localization (dominant hand). All but Subgroup 4 were also impaired on Digit Span.

Subgroup 1 (least proficient) had a relatively lower PIQ than the other subgroups with a particularly low score on Coding. Performance was also relatively poor on Grammatic Closure, Oral Directions and Trail-making. Digit Span, Word Series, Naming and finger localization deficits were noted. Deficits were thus found on cognitive, linguistic and perceptual tasks for the subgroup of least proficient readers.

Subgroup 2 (context cue users, poor comprehenders) had relatively high scores on Coding, *BVRT* copying and Trail-making indicating strength in visual-motor functioning. Word Series, Confrontation Naming and finger localization were below age expectations. Relative deficits were noted in VIQ, Digit Span, *PPVT-R*, Processing Relationships and Ambiguities, Word Associations, and Auditory Discrimination. Weaknesses thus involved both low level and higher level linguistic skills. In reading, Subgroup 2 appeared to be able to use contextual cues for word identification and yet failed to monitor for comprehension, which may be related to the weakness in higher level linguistic skills. However, there was no evidence of a comprehension disorder since performance was not impaired on *WISC-R* Comprehension or on Oral Directions.

Subgroup 3 (low grapho-phonic cue users) performed poorly on *BVRT* copying, *PPVT-R* and Model Sentences, as well as Digit Span, Word Series and Confrontation Naming. Knox Cube test immediate recall, VIQ and PIQ were among the highest scores obtained by the four subgroups. The preponderance of deficits appeared to involve controlled motor movement, particularly of the speech mechanism.

Subgroup 4 (high comprehenders) was the least impaired of the four subgroups on nonreading measures. Subgroup 4 had among the highest scores on VIQ, PIQ, Oral Directions and Grammatic Closure. Relatively low scores, but not in the impaired range, were noted on Arithmetic, Block Design, Object Assembly, and Finger-tapping (dominant hand). Auditory discrimination was poor and this subgroup had the highest level of Tension and Anxiety as rated by teachers. Good performance on a number of language and sequencing measures was thus associated with good comprehension of passages read orally. Poor auditory discrimination may be related to low word attack skills.

Sex did not appear to contribute to differences among the subgroups. Girls were distributed across the four subgroups. Teachers' ratings of arithmetic achievement indicated that all subgroups tended to achieve at normal or borderline levels. Only two subjects, both in Subgroup 1, were underachieving in arithmetic.

Evaluation of the Q Factor Analysis of Eleven Reading Measures

The utility of the overall findings of the Q factor analysis was questionable. Coverage was low for all solutions considered. Large numbers of subjects had high positive loadings on more than one factor. The subjects with double positive loadings did not form a homogeneous "mixed" Subgroup. High negative factor loadings were frequent. Linear dependence among reading measures violated the assumption of linearity making the use of Q factor analysis questionable and preventing the calculation of factor scores to represent the ideal profiles of the subgroups.

The in-depth examination of the four factor solution based on the 11 reading variables revealed weak internal validity. The subgroups were not found to be highly reliable under data manipulation involving the addition of measures to the analysis. Graphic presentations confirmed the distinctiveness of the subgroups in terms of the shape of their profiles across the classification variables and statistical measures confirmed the distinctiveness of the subgroups on all measures except the Graphic and Phonic similarity scales. However, the majority of tests of subgroup differences which reached significance involved Subgroup 1, the children who were the least proficient readers.

Little supporting evidence for the external validity of the subgroups was found. It is possible that the small sizes of the subgroups contributed to the lack of significant differences on nonreading measures as large differences were required to reach significance with such small numbers per subgroup. Nonsignificant trends in the data provided evidence that there are nonreading characteristics which may be related to the differences in reading characteristics of the subgroups.

H. Identification of Subgroups by Cluster Analysis of Reading Measures

The 11 reading measures used previously in Q factor analysis were submitted to cluster analysis. The measures included the three *Woodcock* tests, the five qualitative oral reading scales, and oral reading speed, comprehension and self-corrections. Scores were transformed to z-scores as before. Ward's method of cluster analysis was followed by a relocation procedure. The coverage, internal validity and external validity of the classifications were examined.

Ward's hierarchical clustering procedure begins with each subject representing a cluster and then combines clusters until all subjects are in one cluster. At each step, the decision to combine clusters is based on the size of the error sums of squares which represents the difference between a subject and the centroid of his/her cluster. Clusters which result in the least increase in the error sums of squares are combined. To determine the number of clusters which provides a good solution, the error sums of squares at each step in the hierarchical clustering procedure is examined. Where the error sums of squares "jumps" or increases such that the increase is out of proportion to previous increases, it is an indication that the combining of the previous two clusters created a heterogenous cluster with extensive variance (Morris et al., 1981). Thus, one examines the cluster solution of the step preceding the jump (Veldman, 1967).

When applied to the 11 reading measures, Ward's hierarchical clustering procedure showed a jump in the error term from four clusters (error=4.968) to three clusters (error=7.145). Thus, the four cluster solution was selected. The iterative relocation procedure was applied. Only four subjects were relocated, indicating that the clusters were fairly stable.

Coverage was high with all subjects included in the four subgroups. No outliers, or subjects resisting fusion with other subjects, were evident. The characteristics of the subgroups are described later.

Internal Validity of the Cluster Analysis Subgroups

As was done previously in the evaluation of the Q factor analysis solution, the internal validity of the subgroups identified by the cluster analysis of 11 reading measures was examined. Data manipulation, graphic presentations and statistical procedures were included.

The stability of the four subgroups identified by the cluster analysis of 11 reading measures was evaluated by data manipulation involving the addition of nine reading and spelling variables to the analysis. The variables added were those used previously in the Q factor analysis of 20 reading and spelling measures and included spelling scores and oral reading error types.

Ward's hierarchical cluster analysis of 20 reading and spelling z-scores showed a jump in the error term from three clusters (error=5.038) to two clusters (error=12.155). The three cluster solution was selected. Two subjects were relocated by the iterative relocation procedure (Subject #16 moved from Cluster 2 to Cluster 1; Subject #4 moved from Cluster 3 to Cluster 2). The few relocations indicated the stability of the clusters derived from the analysis of 20 reading and spelling measures.

Three subjects were outliers in the analysis of 20 reading and spelling variables. Subjects #10, #28 and #33 resisted fusion with other subjects up to the three cluster solution. With the outliers omitted, coverage was 94%.

The reliability of the four subgroups identified by the cluster analysis of 11 reading measures was evaluated by comparing these four subgroups with the three subgroups based on 20 reading and spelling measures, excluding the three outliers. Thirty-two of 46 subjects were placed in similar clusters yielding 70% agreement. Of the 14 subjects placed differently, 13 involved separation due to the fourth cluster in the 11 variable analysis. Cluster 4 was composed of nine subjects from Cluster 2 and of four subjects from Cluster 1 of the 20 variable analysis. Only one subject (#1) moved from Cluster 1 to Cluster 3 when the number of variables was reduced from 20 to 11. The results of the two cluster analyses, therefore, showed considerable stability.

A discriminant function analysis yielded both statistical and graphic information relevant to the internal validity of the four subgroups formed by the cluster analysis of 11 reading measures. In order to verify their distinctiveness, the four reading subgroups from the cluster analysis were used as the classification standard in a discriminant function analysis of nonstandardized scores on the 11 reading variables. The results of this analysis must be considered with caution as a conservative use of discriminant function analysis requires a ratio of 10 subjects to each variable. SPSS Program DISCRIMINANT (Nie, Hull, Jenkins, Steinbrenner & Bent, 1975) computes canonical discriminant functions which weight the test scores to maximize the differences among the predefined groups.

Two significant canonical discriminant functions were found. The first significant discriminant function (Wilks lambda=.122, df=16, $p<.01$) involved high positive weights for the Word Identification test and the Phonic similarity scale and a high negative weight for self-corrections. The second discriminant function (Wilks lambda=.418, df=7, p<.01) gave high positive weight to the Semantic acceptability scale and high negative weight to the Phonic similarity scale. On the basis of the derived discriminant functions, all 49 subjects were correctly classified in their respective subgroups.

A graphic presentation of the internal validity of the four subgroups was also provided by the discriminant function analysis. The centroids of the four subgroups are plotted against two discriminant functions in Figure VI.2. The widest separations were between Subgroups 4 versus 3, 1 versus 2 and 1 versus 3. There was a slight overlap of two subjects between Subgroups 2 and 3.

The mean z-score profiles of the four subgroups formed by cluster analysis of 11 reading measures are presented in Figure VI.3. As can be seen from the figure, the four subgroups are distinctive in terms of shape and elevation of their profiles across the classification variables.

Another statistical method for evaluating the internal validity of the four subgroups involved diagnostics provided by the CLUSTAN Package (Wishart, 1978). T values involve comparison of the subgroup mean on each variable with the population sample mean. The relative sizes of the T values were evaluated for descriptive purposes as Morris et al. (1981) suggest caution in the use of these statistics. In Figure VI.3, mean z-scores were plotted allowing one to compare performance of each subgroup against the total population sample mean of zero and standard deviation

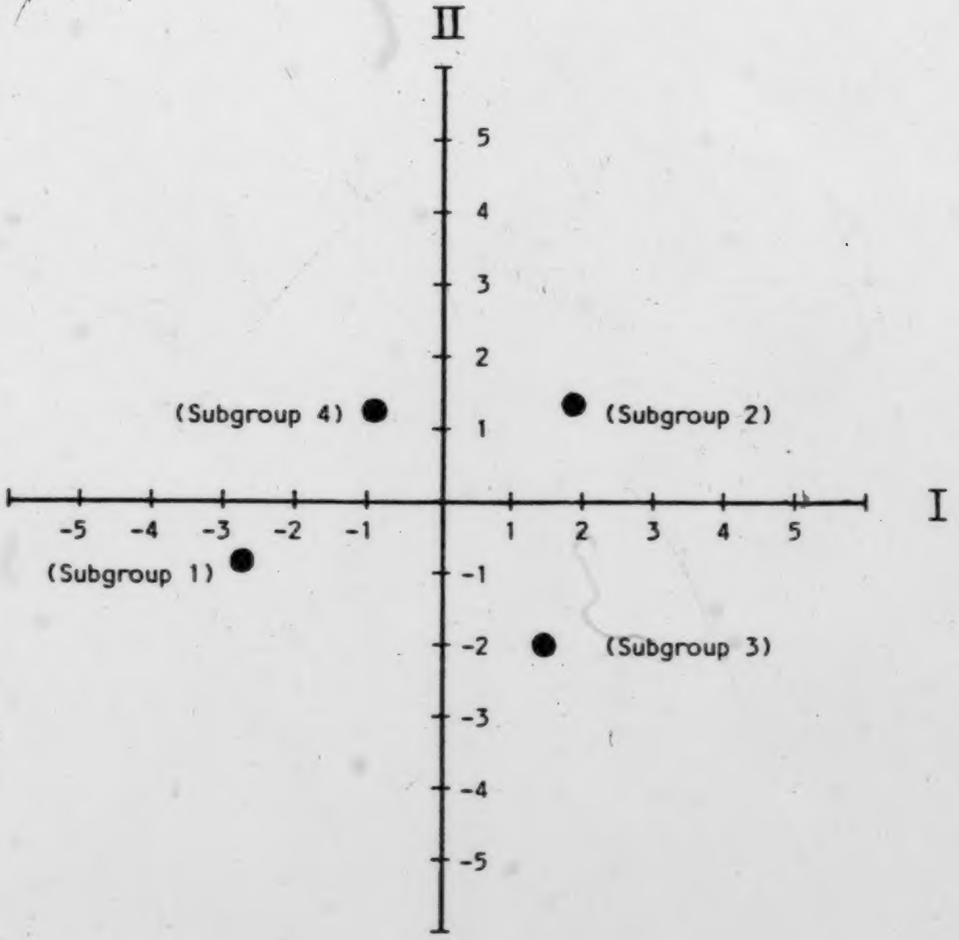


Figure VI.2. Group centroids on discriminant functions I and II for the four subgroups formed by cluster analysis of eleven reading measures.

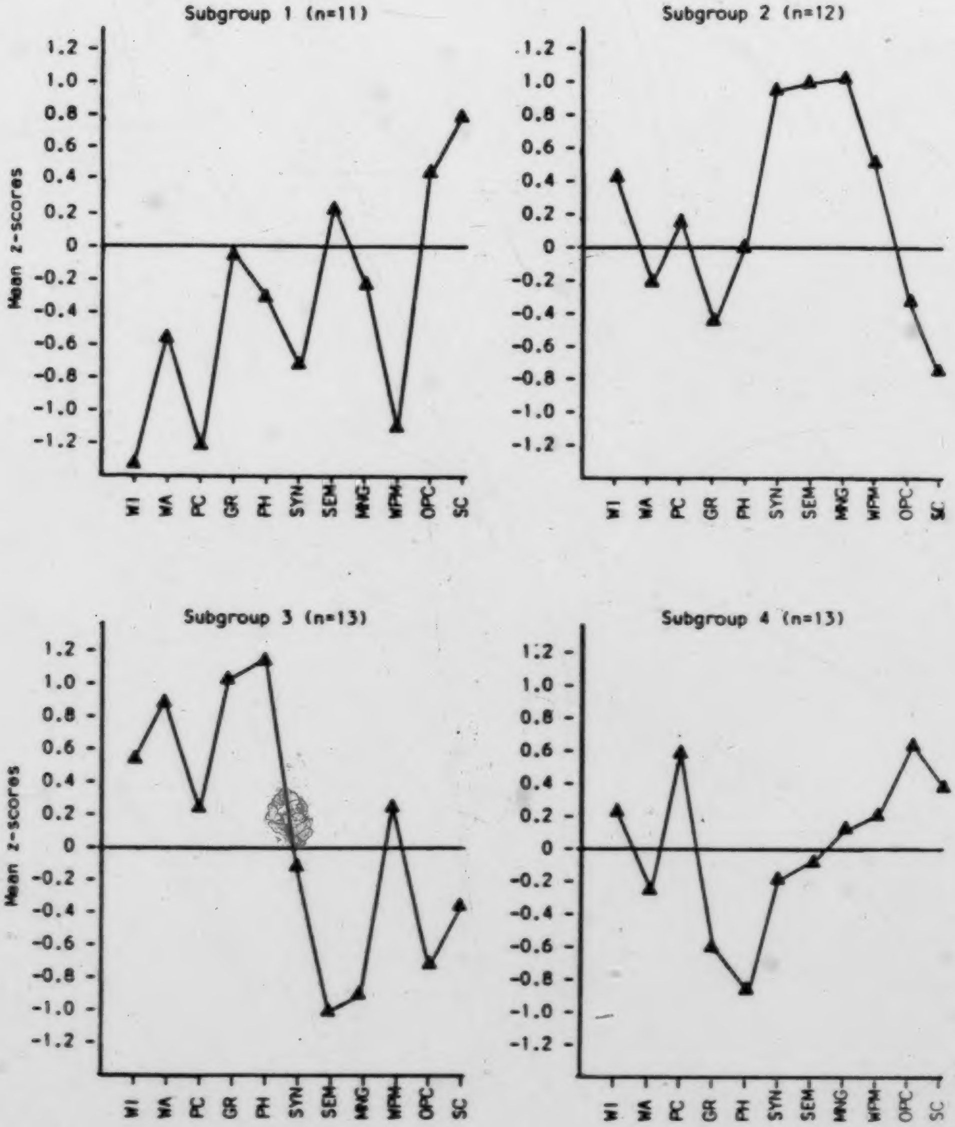


Figure VI.3. Mean z-score profiles across the classification variables for four subgroups formed by cluster analysis of eleven reading measures.

KEY

WI - Word Identification
WA - Word Attack
PC - Passage Comprehension
GR - Graphic similarity
PH - Phonic similarity
SYN- Syntactic acceptability
SEM - Semantic acceptability
MNG - Meaning scale
WPM - Speed of oral reading
OPC - Oral passage comprehension
SC - Self-corrections

of 1.0.

Subgroup 1 was composed of eight boys and three girls. The cluster diagnostics indicated that Subgroup 1 differed from the population sample means on the *Woodcock* Word Identification and Passage Comprehension tests and in the speed of oral reading. Thus, the first subgroup appeared to be composed of the *least proficient and slowest readers*.

Subgroup 2, composed of seven boys and five girls, differed from the population sample means on three qualitative oral reading scales, namely, the Meaning, Semantic and Syntactic acceptabilty scales. Performance on these scales was highest for this subgroup indicating that it was characterized by high use of contextual cues in oral reading. Passage comprehension and self-corrections were below the sample population mean suggesting that this subgroup did not monitor for comprehension (*context cue users, poor comprehenders*).

Ten boys and three girls formed Subgroup 3 which was characterized by relatively high scores on the Graphic and Phonic similarity scales and relatively low scores on the Semantic acceptability and Meaning scales. Oral reading passage comprehension was low. Subjects in Subgroup 3 were high in the *use of grapho-phonic cues*.

The eight boys and five girls in Subgroup 4 differed from the population sample means on the Graphic and Phonic similarity scales, in *Woodcock* Passage Comprehension and in comprehension of oral reading passages. Performance levels were relatively low on the Graphic and Phonic similarity scales and relatively high on the comprehension measures. Thus, Subgroup 4 appeared to be characterized by *high comprehension* and *minimal reliance on graphic and phonic cues*.

Cluster diagnostics evaluated z-scores whereas nonstandardized scores were used in other statistical analyses. The discriminant function analysis yielded a multivariate test of significant differences among the four subgroups on the classification variables. Univariate tests of significance from the discriminant function analysis indicated that there were significant subgroup differences on all 11 reading measures which were used in the classification. Scheffe's multiple comparisons were computed for each variable to determine which subgroups contributed to the significant differences. Subgroup means, standard deviations, F-ratios and the results of Scheffe multiple comparisons are presented in Appendix I.

The comparisons confirmed the distinctiveness of the reading behaviour of the four subgroups. Subgroup 1 was composed of the least proficient readers, as indicated by significantly lower scores compared with the other three subgroups on the *Woodcock* Word Identification and Passage Comprehension tests. Subgroup 1 also read more slowly than the other subgroups. This subgroup tended to make errors which changed the meaning of what was being read and to self-correct, indicating an attempt to monitor for comprehension.

Subgroup 2 (context cue users, poor comprehenders) differed significantly from the other three subgroups on three measures, namely, the Syntactic acceptability, Semantic acceptability and Meaning scales, on which it obtained the highest scores. Thus, this subgroup appeared to attend to the meaning and syntactic and semantic cues available in connected text. However, overall comprehension of the passages read orally was not high.

Subgroup 3 (grapho-phonic cue users) demonstrated superiority in word attack skills as indicated by the highest scores compared with the three other subgroups on the Word Attack test and the Graphic and Phonic similarity scales. The reliance on word attack skills using graphic and phonic cues was found in conjuction with the lowest score on the Semantic acceptability scale, the most meaning change, and low passage comprehension.

Subgroup 4 (high comprehenders) tended to have high comprehension of the oral passages and to make errors which maintained the meaning of the passage. Scores on the Graphic and Phonic similarity scales were low.

External Validity of the Cluster Analysis Subgroups Against Reading and Spelling Measures

The four subgroups formed by the cluster analysis of 11 reading variables were evaluated against reading and spelling measures external to the classification. Spelling grade, spelling grade discrepancy, the percent of phonetically accurate spelling errors, and types of oral reading errors were included in univariate analyses of variance. Means, standard deviations, _F_-ratios and the results of Scheffe multiple comparisons are included in Appendix J.

The subgroups differed on several measures external to the classification variables. Subgroup 1 (least proficient) made significantly more letter order reversal errors and meaningful substitution errors and had a significantly lower spelling grade score than Subgroup 2 (context cue users, poor comprehenders) and Subgroup 3 (grapho-phonic cue users). Subgroup 3 (grapho-phonic cue users) made significantly more nonsense word substitutions than all other subgroups, and also more same affix substitutions and fewer meaningful word substitutions compared with Subgroup 1 (least proficient) and Subgroup 4 (high comprehenders). Subgroup 4 (high comprehenders) omitted significantly more words than Subgroup 1 (least proficient).

External Validity of the Cluster Analysis Subgroups Against Nonreading Measures

Comparisons of the four subgroups on nonreading variables was an important aspect of external validation. Due to the small sizes of the four groups, one way analyses of variance were computed for nonreading measures of IQ, language, memory, sequencing, perception, visual-motor and motor functioning and behaviour ratings. Means and standard deviations of the four subgroups on these measures and the results of the analyses of variance are included in Appendix K.

Significant differences were found for four measures: Similarities, Coding, Trail-making A and Finger tapping (dominant hand). Scheffe post hoc comparisons were not significant for Finger tapping. Scheffe comparisons indicated that Subgroup 4 (high comprehenders) had a significantly higher score on Similarities than Subgroup 3 (grapho-phonic cue users) and Subgroup 2 (context cue users, poor comprehenders). Although Subgroup 2 used contextual cues in oral reading, the members of this subgroup were less concerned about comprehension than Subgroup 4. Grapho-phonic cue users (Subgroup 3) also appeared to be involved with the mechanics of reading rather than with comprehension. Differences on Similarities suggest that good performance on the *WISC-R* subtest may be related to good oral reading passage comprehension since the two lowest scores on Similarities were for Subgroup 2 (context cue users, poor comprehenders) and Subgroup 3 (grapho-phonic cue users) which also had low passage comprehension.

Subgroup 3 (grapho-phonic cue users) had a higher score on Coding and a faster score on Trail-making A than Subgroup 1 (least proficient). The differences between Subgroups 1 and 3 on Coding and Trail-making A may be related to reading proficiency since these two subgroups differed in performance on the *Woodcock* and in speed of oral reading. Subgroup 1 (least proficient) and Subgroup 3 (grapho-phonic cue users) also scored at different levels on the five qualitative scales and in oral reading passage comprehension and self-corrections.

Few differences among subgroups reached significance in analyses of variance, possibly because the sizes of the subgroups were small. Therefore, nonsignificant trends were examined. Overall, Subgroup 4 (high comprehenders) tended to perform above the other subgroups on the *WISC-R* in general, and particularly on verbal subtests. Thus, high verbal skills were found for the subgroup of disabled readers which had the lowest scores on the Graphic and Phonic similarity scales, high scores on two measures of passage comprehension, and a high percentage of self-corrections. Scores on scales reflecting contextual cue use were close to the population sample mean and higher than scores on the Graphic and Phonic similarity scales.

Subgroup 3 (grapho-phonic cue users) was composed of relatively proficient readers. In contrast to Subgroup 4 (high comprehenders), Subgroup 3 tended to be low on most verbal IQ measures and receptive vocabulary (*PPVT-R*) and higher on performance IQ subtests. This subgroup had the largest high PIQ-low VIQ split. The low verbal skills were associated with poor oral reading passage comprehension, low Semantic acceptability and a tendency to change the Meaning of what was being read. This subgroup showed the highest reliance on graphic and phonic cues, had the highest score on the Word Attack test, and made the highest percent of phonetically accurate spelling errors. It also had the highest scores on Digit Span, Coding, Trail-making A and Knox immediate and delayed recall. This subgroup did not have difficulty in finger localization. Proficiency in memory and sequencing may be related to learning and applying spelling-sound correspondence rules.

The poorest readers were in Subgroup 1 (least proficient). This subgroup tended to make equal use of grapho-phonic and contextual cues but used neither well. The members of Subgroup 1 were the slowest readers. They tended to be low on performance IQ measures and had the smallest high PIQ-low VIQ split. Particularly poor performance was noted on Coding, Trail-making A, Digit Span and *CELF* Model Sentences. Speeded tests and sequential processing appeared to be difficult for Subgroup 1.

Subgroup 2 was composed of high context cue users who did not appear to monitor their oral reading for maximum comprehension. Low scores were noted on Similarities, Information, Arithmetic, Digit Span, Word Series, Confrontation Naming and Trail-making B. Finger localization errors were noted for both hands. Lowered comprehension was thus associated with a low score on Similarities. Relatively low use of grapho-phonic cues appeared to be associated with relatively low scores on memory and sequencing tasks.

Sex did not contribute to differences among the subgroups. Girls were distributed across the four subgroups. In comparison with test norms for age nine, all four subgroups were low on Word Series and Confrontation naming. Teachers' ratings of arithmetic achievement indicated normal and borderline achievement for all subgroups. One subject in each of the first three subgroups was underachieving in arithmetic.

Evaluation of the Cluster Analysis of Eleven Reading Measures

The cluster analysis of 11 reading measures had high coverage. Internal validity of the four subgroups was supported by data manipulation, graphic presentations, cluster diagnostics and statistical tests, particularly the multivariate and univariate tests of significance of a discriminant function analysis.

The demonstration of external validity of the subgroups was of major concern. Differences were found among subgroups in spelling achievement and types of oral reading errors.

The interface between reading and nonreading measures was addressed in the external validation of the subgroups against nonreading measures. Significant subgroup differences were found on only four nonreading measures: Similarities, Coding, Trail-making A and Finger tapping (dominant hand). A conservative interpretation of the results is that the data provide weak external validation of the subgroups. However, subgroup sizes were small and only large subgroup differences would reach statistical significance. Nonsignificant trends in the data provided some indication of nonreading performance differences associated with reading behaviour profiles.

I. Comparison of Q Factor Analysis and Cluster Analysis of Eleven Reading Measures

The coverage and internal validity of the subgroups formed by the two types of statistical classification were compared. Cluster analysis has high coverage since only outliers are omitted. The cluster analysis of 11 reading variables identified four subgroups which included the entire sample of 49 subjects. In contrast, coverage was low for the Q factor analysis of these variables (63% to 67%). If subjects who had high positive loadings on more than one factor were omitted, coverage would be further reduced. Cluster analysis was the preferred classification procedure in terms of coverage.

Internal validity was examined by data manipulation involving the addition of variables to the original 11 classification variables. The cluster analysis was preferred over the Q factor analysis on the basis of the greater stability of classified subjects under data manipulation.

Although the Q factor analysis of the 11 reading measures had low coverage, the correspondence between the classifications by the Q factor and cluster analyses were compared to further evaluate the stability of the subgroups and the correspondence among subgroup characteristics and membership.

The descriptions of the subgroups formed by the Q factor analysis and cluster analysis suggested similarities across the procedures: Subgroup 1 of both analyses was described as least proficient, Subgroup 2 as context cue users and poor comprehenders, and Subgroup 4 as high comprehenders. The descriptions of Subgroup 3 of the two analyses did not correspond (low grapho-phonic cue users versus grapho-phonic cue users). The actual subjects classified in the four subgroups by the two statistical procedures showed some correspondence. The number of subjects classified in various combinations of subgroups by the two procedures are cross-tabulated in Table VI.9. Of the 33 subjects classified in four subgroups by the Q factor analysis, 23 subjects (70%) were classified in similar subgroups by the cluster analysis. Subgroup 2 (context cue users, poor comprehenders) and Subgroup 4 (high comprehenders) had the greatest stability across the two procedures. Of the 16 subjects left unclassified by Q factor analysis, 11 were placed in the third subgroup of the cluster analysis (grapho-phonic cue users). There appeared to be fairly high correspondence between the techniques in terms of placing together similar subjects. However, many subjects were not classified by Q factor analysis and the correspondence between the results of the two procedures was

TABLE VI.9
CORRESPONDENCE OF SUBGROUP MEMBERSHIP ACROSS THE Q FACTOR ANALYSIS AND CLUSTER ANALYSIS OF 11 READING MEASURES

Q FACTOR ANALYSIS SUBGROUPS		CLUSTER ANALYSIS SUBGROUPS			
	n	1 (*n*=11)	2 (*n*=12)	3 (*n*=13)	4 (*n*=13)
1	10	6[1]	3[2]	0[3]	1[4]
2	8	0	8	0	0
3	5	0	0	1	4
4	10	1	0	1	8
Unclassified	16	4	1	11	0

[1] Specifies the number of subjects classified in Subgroup 1 by both Q factor analysis and cluster analysis.

[2] Specifies the number of subjects classified in Subgroup 2 by cluster analysis who were classified in Subgroup 1 by Q factor analysis.

[3] Specifies the number of subjects classified in Subgroup 3 by cluster analysis who were classified in Subgroup 1 by Q factor analysis.

[4] Specifies the number of subjects classified in Subgroup 4 by cluster analysis who were classified in Subgroup 1 by Q factor analysis.

only 47% if the total sample was considered. If the 11 unclassified subjects who were placed together in Subgroup 3 of the cluster analysis (grapho-phonic cue users) were considered, the correspondence increased to 69%.

The results presented in this chapter provided evidence that statistical classification procedures will identify internally valid subgroups of disabled readers on the basis of reading characteristics. The nonreading characteristics of these subgroups were considered. In the next chapter, subgroups formed on the basis of nonreading characteristics will be described. The correspondence among subgroups based on the two types of measures will be presented and the interface between nonreading and reading characteristics will be considered.

VII. Results of the Analyses of Nonreading Measures

The majority of classification studies have attempted to identify subgroups of disabled readers on the basis of nonreading test performance characteristics. In the present study, the nonreading data included the assessment of skills in several areas: intelligence; language; auditory, visual and tactile perception; memory and sequencing; and visual-motor and motor functioning. Teachers also rated each child in terms of arithmetic achievement and classroom behaviour.

Prior to the central problem of the identification of subgroups, the characteristics of the sample of disabled readers were examined. Possible sample heterogeneity associated with differences among subjects in age and sex was examined in relation to performance on the nonreading measures as they had been examined previously in relation to reading variables. The heterogeneity of the sample in performance on the battery of nonreading measures was also examined. Where appropriate, the performance levels of the disabled readers were compared to test norms. Relationships among nonreading measures for the sample were examined in correlational and R factor analyses. Relationships among the nonreading measures and reading and spelling measures were also examined in correlational analyses. Finally, two statistical classification procedures were applied to nonreading variables to identify homogeneous subgroups of disabled readers. As in the previous chapter, the coverage, internal validity and external validity of the statistical classification solutions were evaluated. The correspondence among subgroups formed on the basis of reading measures and subgroups formed on the basis of nonreading measures was considered.

A. Age and Sex Characteristics of the Total Sample in Relation to Nonreading Measures

The factors of age and sex were examined to determine their contribution to sample heterogeneity in performance on nonreading measures. The feasibility of collapsing across these variables for further analyses was evaluated.

Multivariate and univariate tests (SPSS MANOVA, Hull & Nie, 1981) were computed comparing 9-year-olds and 10-year-olds and boys and girls. The large number of nonreading measures was divided into five groups of variables for the multivariate analyses: 1) IQ measures included VIQ, PIQ, FSIQ and 11 *WISC-R* subtests; 2) language measures included *PPVT-R*, Grammatic Closure, Sound Blending and nine scores from the *CELF* subtests; 3) memory measures included the Knox Cube Test and *BVRT*; 4) 12 neuropsychological test scores included motor and perceptual tasks, Right-left discrimination, Trail-making and the Rhythm test; 5) teachers' ratings of classroom behaviour and arithmetic achievement comprised the fifth group of variables. The results of the overall multivariate tests are presented in Table VII.1.

TABLE VII.1
RESULTS OF MULTIVARIATE ANALYSES OF NONREADING MEASURES FOR COMPARISONS ACROSS AGE AND SEX

VARIABLES	AGE	SEX
	_F_-ratio¹	_F_-ratio¹
1. IQ Measures (14 scores)	1.53 (df=14,34)	2.093* (df=14,34)
2. Language Measures (13 scores)	4.45** (df=13,35)	1.93 (df=13,35)
3. Memory Measures (6 scores)	2.24 (df=6,42)	0.63 (df=6,42)
4. Neuropsych. (12 scores)	0.810 (df=12,36)	0.484 (df=12,36)
5. Teachers' Behavior Ratings (6 scores)	0.788 (df=6,42)	2.813* (df=6,42)

* $p < .05$
** $p < .01$
1. Multivariate _F_-test from SPSS MANOVA.

Age comparisons indicated a significant difference between 9- and 10-year-olds on language measures only. Univariate tests of the 13 language scores indicated that 10-year-olds performed at significantly higher levels than the 9-year-olds on five *CELF* scores: Oral Directions ($\underline{F}$=5.09, df=1,47, $\underline{p}$<.05); Word Series accuracy and time ($\underline{F}$=12.20, df=1,47, $\underline{p}$<.01 and $\underline{F}$=10.01, df=1,47, $\underline{p}$<.01, respectively); Confrontation Naming time ($\underline{F}$=16.41, df=1,47, $\underline{p}$<.05); and Model Sentences ($\underline{F}$=4.33, df=1,47, $\underline{p}$<.05).

No other multivariate test comparing 9- and 10-year-olds reached significance. The *CELF* test differences were expected as only raw scores were available with no conversion to age-corrected standard scores. It was concluded that the overall lack of age differences indicated that the data for the 9- and 10-year-olds could be combined for further analyses.

Multivariate tests of sex differences between the 33 boys and 16 girls in the present sample were significant for IQ and behaviour ratings. The boys obtained significantly higher Verbal IQ scores ($\underline{F}$=5.19, df=1,47, $\underline{p}$<.05) and Information subtest scores ($\underline{F}$=17.33, df=1,47, $\underline{p}$<.01). Teachers rated boys significantly more poorly than girls on the Conduct Problem and Hyperactivity scales of the Conners Teacher Questionnaire ($\underline{F}$=7.08, df=1,47, $\underline{p}$<.05 and $\underline{F}$=12.21, df=1,47, $\underline{p}$<.01, respectively). Few significant differences were detected and it was concluded that sex differences did not contribute substantially to sample heterogeneity. Boys and girls were combined for further analyses.

B. Nonreading Test Performance of the Total Sample

Average levels of performance and variability in performance on the nonreading measures were examined to describe the total sample and the sample heterogeneity expected within a multiple-syndrome paradigm. Means and standard deviations based on the total sample of 49 disabled readers were calculated for the battery of nonreading measures. Performance levels of individual subjects were compared to test norms where published norms were available to determine the number of disabled readers experiencing difficulty in the areas assessed. The characteristics of the sample are presented below, dividing the measures in terms of the areas assessed: IQ, language, memory and neuropsychological measures, and behaviour ratings.

IQ Scores

Means and standard deviations for *WISC-R* scores and for the discrepancy between Verbal IQ and Performance IQ (PIQ-VIQ) are presented in Table VII.2. The percent of subjects scoring more than one standard deviation below subtest means (i.e., scale scores less than 7) are also noted in Table VII.2. As can be seen from the mean scores, the sample of disabled readers tended to perform at higher levels on the performance subtests compared to the verbal subtests of the *WISC-R*, with the lowest mean scores on Digit

TABLE VII.2
WISC-R PERFORMANCE LEVELS OF THE TOTAL SAMPLE

WISC-R SCORES	$\overline{X}$	SD	% Ss SCORING BELOW 7 (SUBTESTS)
Verbal IQ	96.8	8.9	
Performance IQ	104.2	9.8	
Full Scale IQ	100.0	8.2	
PIQ-VIQ	7.4	11.2	
Information[1]	8.9	2.1	10
Similarities	10.0	2.2	4
Arithmetic	8.8	2.3	18
Vocabulary	10.0	1.9	4
Comprehension	10.0	2.3	2
Digit Span	7.7	2.5	39
Picture Completion	11.1	2.4	4
Picture Arrangement	11.3	2.2	2
Block Design	10.6	2.5	4
Object Assembly	10.8	2.1	0
Coding	9.2	2.4	10

[1] Subtest scores are scale scores.

Span, Arithmetic, Information and Coding.

A large proportion of subjects had a low VIQ-high PIQ split on the *WISC-R*. For nineteen subjects (39%), PIQ was 10 to 20 points higher than VIQ and 21 or more points higher for five subjects (10%). Twenty-two subjects (45%) had a discrepancy of less than 10 points. Only two subjects (6%) had a high VIQ-low PIQ split of 10 to 20 points, and only one subject had a high VIQ-low PIQ split of more than 21 points.

Examination of the frequency of subjects experiencing particular difficulty on each *WISC-R* subtest indicated that a substantial number of subjects performed poorly on the Digit Span subtest. Scores on Arithmetic, Information and Coding were also particularly low for some subjects.

Language Tests

Means, standard deviations and the percent of subjects scoring at low levels compared to language tests norms are presented in Table VII.3. As can be seen from Table VII.3, large numbers of subjects performed poorly on several language measures with at least one-fourth of the sample with low scores on nine of the 13 tests.

The language measures were selected to sample across phonological, syntactic and semantic level processing (see Table V.3). The disabled readers experienced difficulty at all levels of linguistic processing. Impairment of lower level linguistic processes, however, appeared to be more

TABLE VII.3
LANGUAGE TEST PERFORMANCE OF THE TOTAL SAMPLE

LANGUAGE TESTS	$\overline{X}$	SD	% Ss WITH DIFFICULTY
PPVT-R[1]	94.8	8.9	14
Grammatic Closure[2]	30.9	7.9	35
Sound Blending[2]	38.8	4.3	4
CELF[3]			
Word And Sentence Structure	82.6	7.3	29
Relationships And Ambiguities	71.9	7.8	35
Oral Directions	77.1	13.1	41
Word Series: Accuracy	80.0	8.7	71
Word Series: Time (Sec.)	18.8	11.6	16
Confrontation Naming: Accuracy	80.8	8.7	78
Confrontation Naming: Time (Sec.)	83.5	21.2	53
Word Associations (Tot. No.)	31.9	6.8	6
Model Sentences	62.3	12.5	27
Auditory Discrimination	97.1	2.8	24

1. The standard score is reported. Subjects with difficulty scored more than one SD (15) below the test $\overline{X}$ (100), i.e. below 85.
2. Scale scores are reported. Subjects with difficulty scored more than one SD (6) below the test $\overline{X}$s (36), i.e. below 30.
3. Unless specified otherwise, the percent correct is reported for *CELF* tests. Subjects with difficulty scored below criterion scores representing the score at the 20th precentile for a grade 4 norming sample reported in the 1982 publication manual.

widespread than impairment of higher level linguistic processes.

The majority of the sample performed at low levels on Word series accuracy and Confrontation Naming, both of which involve primarily low level phonological processes. Phonological processing difficulties were experienced by some subjects on the Auditory Discrimination test, but by few subjects on Sound Blending. Substantial numbers of subjects performed poorly on several measures of semantic and/or syntactic processing: Grammatic Closure, Word and Sentence Structure, Relationships and Ambiguities, Oral Directions and Model Sentences.

Although several measures which resulted in poor performance by many of the disabled readers involved semantic processes, few subjects had difficulty on other semantic processing measures, namely, *PPVT-R* receptive vocabulary, Word Associations requiring the retrieval of semantically related items from long term memory, and *WISC-R* Information, Similarities, Vocabulary and Comprehension subtests.

Memory and Neuropsychological Tests

Many of the nonreading measures presented above are included in neuropsychological test batteries. Other tests commonly used in neuropsychological assessments to measure memory, tactile and auditory perception, motor and visual-motor functioning are described below. Means and standard deviations obtained by the present sample on these measures are presented in Table VII.4. Where available, test norms for age nine are included in the table for comparison purposes along with the percent of subjects experiencing difficulty on the task.

Several IQ and language tests discussed in the previous sections involved memory processes. Substantial numbers of disabled readers performed at low levels on tasks involving auditory sequential memory: Digit Span, Word Series and Model Sentences. Good performance was noted for Word Associations involving the number of semantically related items retrieved from long term memory. As can be seen from Table VII.4, few subjects had difficulty on the Rhythm test which required that they remember and compare patterns of auditory beeps. Thus, verbal auditory stimuli contributed to greater difficulty than nonverbal auditory rhythms.

Visual memory tasks included the Knox Cube test and the *BVRT*. As can be seen from Table VII.4, few subjects experienced difficulty on the sequential visual memory tasks (Knox) or on the nonsequential visual memory task (*BVRT*). Norms were not available for Knox delayed recall which was more difficult than immediate recall for these subjects. Auditory sequential tasks were thus more difficult than visual memory tasks for the present sample of disabled readers.

Right-left discrimination was performed without errors by 21 subjects. Fifteen subjects could discriminate right

TABLE VII.4
MEMORY AND NEUROPSYCHOLOGICAL
TEST PERFORMANCE OF THE TOTAL SAMPLE

MEASURES	PERFORMANCE OF PRESENT SAMPLE		TEST NORMS FOR AGE NINE		% Ss WITH DIFFICULTY
	$\overline{X}$	SD	$\overline{X}$	SD	
KNOX CUBE TEST[1]					
Mental Age	11.6	3.5	10.4	3.2	10
Immediate Recall	10.9	2.1	9.7	2.4	6
Delayed Recall	8.8	2.2			
BVRT[2]					
Memory	5.4	1.8	4-6		16
Copying	8.0	1.5			
RHYTHM[3]					
(# correct)	21.7	3.4	21.0	4.9	8
FINGER RECOG.[3]					
(# errors)					
Dominant (Dom)	1.5	1.7	1.0	0.5	24
Nondominant (Non)	1.7	1.8	1.0	1.0	31
Dom-Non	-0.2	1.7			
FING. NO. WRIT.[4]					
(# errors)					
Dominant	4.4	3.1	4.4	3.8	12
Nondominant	4.8	2.9	4.6	3.2	12
Dom-Non	-0.5	2.4			
FING. TAP.[4]					
Dominant	35.9	3.6	31.8	4.4	0
Nondominant	32.8	4.2	29.2	3.7	0
Dom-Non	3.1	3.1			
GROOV. PEGB.[4]					
(time)					
Dominant	75.2	10.3	74.0	15.0	10
Nondominant	85.4	13.6	80.0	15.1	18
Dom-Non	-10.2	10.6			
TRAIL MAK.[4]					
(time)					
A	19.2	7.0	21.5	7.5	2
B	47.9	29.8	49.5	17.0	10

1. Norms for Mental Age conversions and immediate recall are based on a clinic sample (Trites, 1977). Subjects with difficulty scored more than one standard deviation below the mean for a clinic sample of 9-year-olds.
2. Norms for the memory administration are from the Revised Visual Retention Test (Benton, 1963). No other norms were available. Subjects with difficulty had fewer than four correct reproductions.
3. Norms are based on a clinic sample (Trites, 1977). Subjects with difficulty scored more than one standard deviation below the mean score for age nine.
4. Norms are from Knights (1970). Subjects with difficulty scored more than one standard deviation below the mean score of the age nine normative sample.

and left on their own body, but not on a picture of a boy facing them. The remaining 13 subjects made a variety of errors. Knowledge of left and right was not well established for half of the sample of disabled readers.

As can be seen from Table VII.4, few subjects experienced difficulty on motor and visual-motor tasks including *BVRT* copying, Finger-tapping, Grooved Pegboard and Trail-making. Perceptual and motor tasks which assessed both dominant and nondominant hand performance showed the expected superiority of the dominant hand over the nondominant hand. Only two subjects, one boy and one girl, showed preference for the left hand on the lateral dominance examination. At least one fourth of the sample had difficulty in finger recognition.

Behaviour Ratings

Teachers rated each subject on items assessing classroom behaviour (*Conners Teacher Questionnaire*) and arithmetic achievement. Means and standard deviations for the total sample on the behaviour scales are presented in Table VII.5. Large standard deviations indicated considerable variability in scores. On the average, Conduct Problems were infrequent whereas Inattentive-passive behaviour was quite prevalent among the disabled readers. A score of 50% or higher on the Hyperactivity scale has been considered a critical cut-off score to denote hyperactive behaviour (e.g., Trites, 1979). Only six subjects obtained a

TABLE VII.5
BEHAVIOUR RATINGS OF THE TOTAL SAMPLE

CONNERS TEACHER SYMPTOM QUESTIONNAIRE	$\overline{X}$	SD
Conduct Problems	8.57	15.53
Inattentive-Passive	37.02	19.64
Tension-Anxiety	24.90	20.23
Hyperactivity	20.02	20.03

score of 50% or higher on the Hyperactivity scale.

Arithmetic achievement was rated by teachers as normal, borderline, or underachievement. Twenty-four subjects were achieving normally in arithmetic, 22 had borderline achievement and three were rated as underachieving.

C. Correlations among Nonreading Measures

Pearson product moment correlations were calculated among the nonreading measures for the total sample of 49 disabled readers. A correlation matrix containing tests for which correlation coefficients were .40 and higher is presented in Table VII.6. The magnitude of the correlations was selected as it reflected 16% of common variance. Twenty-three tests are excluded from the tables as they did not correlate at a .40 level with any other test. Few inter-correlations were high: only 27 of approximately 1400 inter-correlations were .40 or higher.

Within the IQ, language and memory skill areas, few inter-correlations were of a substantial magnitude. The few high inter-correlations within each of these skill areas suggests that the measures tapped independent aspects of IQ, language and memory functioning.

Greater dependence among measures was noted within the sensory and motor skill areas. Correlations were particularly high between dominant and nondominant hand scores for each test.

TABLE VII.6

CORRELATIONS AMONG NONREADING MEASURES[1].

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1 Information																														
2 Arithmetic																														
3 Vocabulary																														
4 Comprehension																														
5 Digit Span																														
6 Picture Completion																														
7 Block Design																														
8 PPVT-R	58		50	41																										
9 Grammatic Closure																														
10 Sound Blending																														
11 Oral Directions		53																												
12 Word Series: Accuracy																														
13 Word Series: Time												-70																		
14 Naming: Accuracy																														
15 Naming: Time																														
16 Word Associations																														
17 Model Sentences					43					44																				
18 Auditory Discrim.														41																
19 Finger Recog: Dom															42		-40													
20 Finger Recog: Nondom																			53											
21 #writing: Dom																	-50		45	42										
22 #writing: Nondom																					66									
23 Finger tap: Dom																														
24 Finger tap: Nondom																							68							
25 Pegboard: Dom																								-43						
26 Pegboard: Nondom												-43	48											-45	64					
27 Trail making: A															57	-46							46							
28 Trail making: B						-44																								
29 Knox: Delay									43																					
30 Benton Copying							46																							

1. Decimal points are omitted.

Few correlations across the various skill areas were high, i.e., .40 or greater. Relationships were observed between language tests and motor and sensory measures, between verbal subtests of the *WISC-R* and both receptive vocabulary (*PPVT-R*) and *CELF* subtests, and between *WISC-R* performance subtests and neuropsychological measures. Overall, the low correlations among measures of the psychological and neuropsychological test battery indicated that independent skills were assessed by these tests.

D. R Factor Analysis of Nonreading Measures

An R factor analysis of selected nonreading measures was computed to determine the dimensions assessed and to reduce the large number of variables for further analyses. The number of variables was reduced to 28 to achieve a subject to variable ratio more acceptable for an R factor analysis. Variables were omitted for several reasons: the majority of the disabled readers did not experience difficulty in relation to test norms (Finger-tapping, Grooved Pegboard, Fingertip Number Writing, Trail-making A were omitted); two parts of the test were highly correlated (Finger Recognition non-dominant hand score, Word Series time score were omitted); little variability in test scores (Right-left discrimination and Auditory Discrimination were omitted); particular interest in one of two scores available for a test (Confrontation Naming accuracy was omitted). The reliability of teachers' behaviour ratings was questionable and standard deviations were very large for the behaviour scales (teachers' ratings were omitted).

A principal components analysis with varimax rotation yielded 11 factors with eigenvalues of 1.0 or greater, accounting for 76% of the total variance (DERS PROGRAM FACT20, 1980). A four factor solution accounting for 42% of the total variance was most interpretable. Factor loadings of each test on the four factors are presented in Table VII.7. The highest loadings on each factor are underlined. The first factor was considered to be a Verbal factor, the second an Auditory sequencing factor, the third a Spatial/visual-motor factor, and the fourth a Memory/sequencing factor, mainly visual. The factor loadings of the 28 variables on the four factors were used to compute factor scores to be used in statistical classification analyses described in a later section.

E. Correlations among Reading and Nonreading Measures

Relationships among reading and nonreading measures were explored in correlational analyses. Few high correlations were observed with six correlations of .40 or higher and 27 correlations of .30 or higher.

Woodcock tests were correlated with both Word Identification (r=.31) and Passage Comprehension (r=.31). Picture Completion was also correlated with Passage Comprehension (r=.42). Three measures which involved sequential processing correlated highly with Word Attack,

TABLE VII.7

SUMMARY OF AN R FACTOR ANALYSIS OF 28 NONREADING MEASURES[1]

	FACTORS 1	2	3	4
WISC-R:				
Information	77	-03	12	-03
Similarities	55	08	-11	-19
Arithmetic	23	24	53	23
Vocabulary	78	24	09	10
Comprehension	56	-02	07	-02
Digit Span	-10	58	24	16
Picture Completion	32	-10	33	-02
Picture Arrangement	30	-33	35	23
Block Design	27	06	66	06
Object Assembly	03	-24	50	13
Coding	-16	-07	26	44
PPVT-R	78	-00	06	02
ITPA:				
Grammatic Closure	37	37	-14	22
Sound Blending	00	65	-27	10
CELF:				
Word & Sentence Structure	35	-01	19	08
Relationships & Ambiguities	14	36	03	29
Oral Directions	14	33	54	14
Word Series (Accuracy)	09	48	37	-25
Confront. Naming (Time)	39	-42	-30	-45
Word Association	32	22	-12	53
Model Sentences	19	77	16	01
Finger Recognition: (Dominant, Errors)	13	-46	-44	07
Trail-making B (Time)	-07	-04	-55	01
Rhythm	00	46	-05	-18

CONTINUED....

TABLE VII.7 (Continued)

SUMMARY OF AN R FACTOR ANALYSIS OF 28 NONREADING MEASURES[1]

	FACTORS			
	1	2	3	4
Knox Cube Test:				
Immed. Recall	-08	-11	21	53
Delayed Recall	08	39	-02	64
BVRT				
Memory	00	-15	05	62
Copying	-20	04	59	10
Percent of Total Variance	12.33	11.00	10.53	7.98

1. Factor loadings are given for each test; decimal points are omitted.

namely, Digit Span (r=.38), Confrontation Naming time (r=-.37) and Model Sentences (r=.33).

Comprehension of the passages read orally was correlated with Picture Arrangement (r=.39) and with verbal measures including Verbal IQ (r=.39), Information (r=.41) and *PPVT-R* (r=.41). The correlations suggested that verbal skills enhanced reading comprehension.

Self-corrections and speed of oral reading were correlated with Coding (r=-.42 and r=.47, respectively). Children who self-correct frequently are slower readers. Thus, the correlations suggest that speed of processing, particularly in manipulating symbols, may be involved in Coding and oral reading speed.

The Graphic and Phonic similarity scales were highly correlated with Digit Span (r=.30 and r=.36, respectively). Graphic similarity was negatively correlated with *PPVT-R* (r=-.30) and with Finger recognition (dominant hand) (r=-.33). Phonic similarity was negatively correlated with Vocabulary (r=-.36) and Confrontation Naming time (r=-.32). These relationships, together with the correlations between memory/sequencing tasks and Word Attack, suggest that children who show facility in remembering and applying spelling-to-sound correspondence rules tend to also perform well on auditory sequential memory tasks and on a rapid naming task. The naming task requires rapid responses to visual stimuli, as does Word Attack.

The Semantic acceptability scale was correlated with the Knox Cube test delayed recall (r=-.37) and the Meaning scale with immediate recall (r=-.31). The negative direction of the relationships suggests that children who make oral reading errors which are contextually appropriate tend to do more poorly on measures of sequential memory.

The Meaning scale and receptive vocabulary *PPVT-R* were correlated (.30). As noted above, oral passage comprehension and *PPVT-R* were also related. Thus, higher receptive vocabulary was associated with greater comprehension and maintenance of passage comprehension.

F. Identification of Subgroups by Q Factor Analysis of Nonreading Measures

The battery of nonreading measures included a large number of variables. As was done previously, scores were transformed to z-scores and the matrix was transposed for Q factor analysis. Three groups of variables were included in separate principal component analyses with varimax rotation: 53 variables, 28 variables, and 12 variables (DERS PROGRAM FACT20, 1980). The results of various factor solutions for the Q factor analyses are summarized in Table VII.8.

First, the complete nonreading battery of psychological and neuropsychological measures and behaviour ratings was included in a Q factor analysis. Positive factor loadings of .40 and higher define subgroup membership. As can be seen

TABLE VII.8
SUMMARY OF THE RESULTS OF Q FACTOR ANALYSES OF THREE GROUPS OF NONREADING VARIABLES

	FACTOR SOLUTION 6	5	4	3
	53 Nonreading Variables			
% Total Variance Accounted For	46	41	36	29
% Classified[1]	53	47	37	39
% Double Loadings[2]	0	0	2	4
% Negative Loadings[3]	35	37	33	25
	28 Nonreading Variables			
% Total Variance Accounted For	50	44	37	29
% Classified[1]	53	43	41	40
% Double Loadings[2]	6	0	0	0
% Negative Loadings[3]	51	59	59	63
	12 Nonreading Variables			
% Total Variance Accounted For	78	69	59	48
% Classified[1]	63	55	55	47
% Double Loadings[2]	14	8	4	4
% Negative Loadings[3]	59	49	53	39

1. Positive factor loadings $\geq .40$ defined classification.
2. Double loadings refer to positive loadings $\geq .40$ on more than one factor.
3. Negative loadings refer to factor loadings $\leq -.40$.

from Table VII.8, the Q factor analysis of 53 nonreading measures had low coverage, leaving 47% to 61% of the sample of disabled readers unclassified. The utility of subgroups representing so few disabled readers was questionable. High negative factor loadings were noted. The internal and external validity of the subgroups identified by this analysis were not evaluated. It was decided that more meaningful subgroups might be identified on the basis of a reduced number of nonreading measures.

The second group of nonreading variables submitted to Q factor analysis included the reduced battery of 28 variables previously described for the R factor analysis of nonreading measures. The results of various factor solutions were summarized in Table VII.8. The low coverage, small subgroup sizes and frequent high negative loadings weakened the utility of the subgroups formed by the Q factor analysis of 28 nonreading measures. These subgroups were not examined further.

Further data reduction was undertaken in an attempt to find a Q factor analysis solution with greater coverage. The 28 nonreading measures used in the Q factor analysis described above were previously included in an R factor analysis which yielded four interpretable factors. The three measures which had the highest loadings on each factor were selected to represent four dimensions of nonreading performance: a Verbal factor (Information, Vocabulary, *PPVT-R*); an Auditory sequencing factor (Model Sentences, Sound Blending, Digit Span); a Spatial/visual-motor factor (Block Design, *BVRT* copying administration, Trail-making B) and, a Memory/sequencing factor (Knox Cube test delayed recall, *BVRT* memory administration, Word Associations). As can be seen from Table VII.8, the factor solutions had low coverage. Double high positive factor loadings, small subgroup sizes, and numerous high negative factor loadings also limited the utility of the classifications.

The correspondence among the Q factor analyses of 53, 28 and 12 nonreading variables was examined by comparing the six factor solutions of the three analyses. Subject classifications varied across all analyses. Only 16 to 18 subjects were classified by two Q factor analyses and few of these were placed together as similar by more than one analysis. The low coverage and variability in results argued against the utility of the Q factor analysis classifications and they were not investigated further.

G. Identification of Subgroups by Cluster Analysis of Nonreading Measures

Cluster analysis was applied to three groups of nonreading variables: 28 measures included previously in R factor and Q factor analyses; 12 measures which had high loadings on four factors from the R factor analysis of nonreading measures; and, factor scores representing the four factors from the R factor analysis.

First, Ward's hierarchical cluster analysis of the reduced set of 28 nonreading measures indicated selection of the nine factor solution as the error term jumped from 39.86 for nine clusters to 44.10 for eight clusters. Three clusters were eliminated as they represented a total of only five subjects (Subjects #5, #41; #12; #19, #24). Coverage was high with 44 subjects (90%) in the remaining six subgroups, each of which consisted of five to ten subjects. The error terms associated with each cluster solution in the hierarchy were high and the interpretation of profiles across such a large number of variables was complex. Thus, the subgroups identified by this analysis were not examined further.

Data reduction appeared to be needed to increase interpretability and to decrease the error terms. As described previously in the Q factor analysis section, the three measures which had the highest loadings on four factors in an R factor analysis were selected for inclusion in a cluster analysis. A total of 12 variables represented the Verbal, Auditory sequencing, Spatial/visual-motor and Memory/sequencing factors. Ward's cluster analysis of z-scores of the 12 nonreading measures indicated selection of a six cluster solution. The error term jumped from six clusters (4.219) to five clusters (5.572). Four "outliers" were identified (Subjects #3, #30, #38 and #19).

The six cluster solution of the iterative relocation procedure was compared to Ward's six cluster solution.

Again, Subjects #19 and #30 were outliers, resisting fusion with other clusters. For the remaining 47 subjects (96%) comprising five clusters, 11 subjects were relocated. The subgroups were not examined further as instability was indicated by the high number of relocations.

An alternative method of data reduction involved using factor scores from the R factor analysis of 28 nonreading measures. The factor loadings derived from the R factor analysis were applied to the nonstandardized data of the 49 subjects to derive factor scores. The factor scores represented a Verbal factor, an Auditory sequencing factor, a Spatial/visual-motor factor, and a Memory/sequencing factor.

Ward's hierarchical cluster analysis of the factor scores resulted in an increase in the error score from five clusters (error=5.452) to four clusters (error=10.345). Thus, the five cluster solution was selected. The five cluster solution of the relocation procedure indicated that six subjects had been relocated. The cluster solution had stability and internal and external validity were examined.

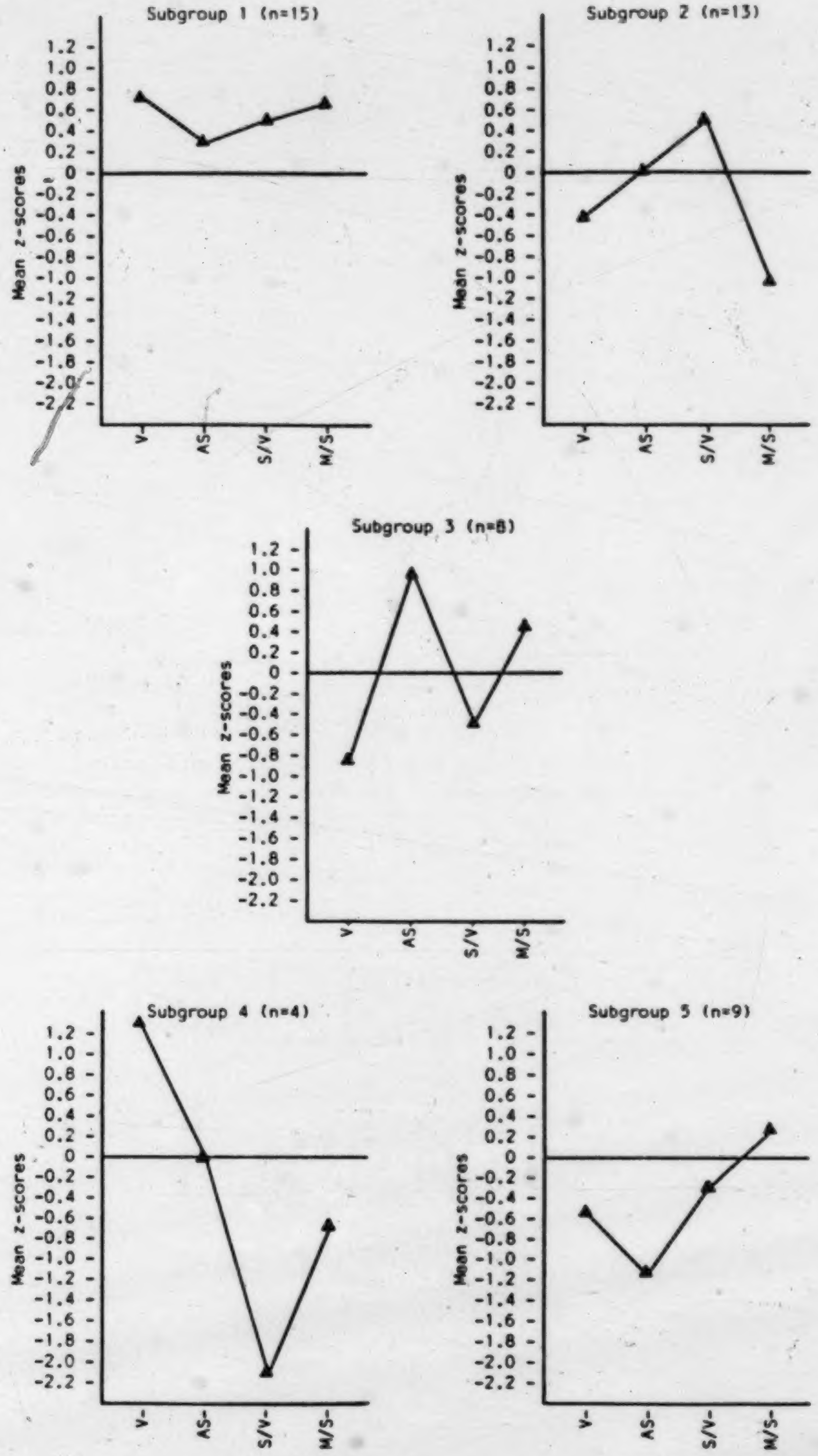
Internal Validity of Subgroups Formed by Cluster Analysis

The internal validity of the five subgroups formed by cluster analysis of four nonreading factor scores was examined in several ways. Data manipulation, graphic presentations and statistical procedures were used.

A form of data manipulation to evaluate internal validity involved comparisons with cluster analysis solutions for other groups of variables. The factor scores represented four factors derived from an R factor analysis of 28 nonreading measures. The results were compared with the results of cluster analyses of the 28 variables from which the factor scores were derived, and of 12 variables which had high loadings on the four factors. This form of data manipulation to assess the stability of the cluster analysis solution based on factor scores may be a weak procedure in view of the lack of stability of the 28 and 12 variable solutions. Cluster analyses of the 28 nonreading variables and of the four factor scores grouped together 26 subjects (53%) in similar ways. Cluster analyses of the 12 variables and four factor scores showed little consistency with only 15 subjects grouped together in similar ways by the two analyses.

Graphic procedures to evaluate internal validity included factor score profiles. The mean factor scores obtained by the five subgroups formed by the cluster analysis of four nonreading factor scores are plotted in Figure VII.1. The factor score profiles of the five subgroups were distinctive in terms of shape and/or elevation across the four classification factor scores.

Statistical evaluation of internal validity involved cluster diagnostics from the CLUSTAN Package (Wishart, 1978) and univariate analyses of variance examined to verify the


Subgroup 1 (n=15)

Subgroup 2 (n=13)

Subgroup 3 (n=8)

Subgroup 4 (n=4)

Subgroup 5 (n=9)

Figure VII.1. Mean z-score profiles across the classification variables for five subgroups formed by cluster analysis of four nonreading factors.

KEY

V - Verbal factor

AS - Auditory sequencing factor

S/V - Spatial/Visual-motor factor

M/S - Memory/Sequencing factor

distinctiveness of the five subgroups on the classification factor scores. Cluster diagnostics provided information about the characteristics of each subgroup in relation to the average performance of the total sample. Univariate analyses of variance provided information about differences among the subgroups on the four factors. The analyses indicated significant differences on all four factors, i.e., on the Verbal factor ($\underline{F}$=12.0, df=4,44, $\underline{p}<.01$), the Auditory sequencing factor ($\underline{F}$=17.63, df=4,44, $\underline{p}<.01$), the Spatial/visual-motor factor ($\underline{F}$=12.17, df=4,44, $\underline{p}<.01$) and the Memory/sequencing factor ($\underline{F}$=13.13, df=4,44, $\underline{p}<.01$). Scheffe multiple comparisons with the probability level set at .10 were computed to determine which subgroups differed on various factors. The characteristics of the profile of each subgroup will be described, followed by a description of significant differences among the subgroups on the four classification factors.

Subgroup 1 was the largest group consisting of 14 boys and one girl. Subjects in this subgroup were characterized by relatively good performance on the four nonreading factors. Thus, in comparison with the mean performance levels of the sample, Subgroup 1 may be referred to as *average performers*. The mean factor scores for Subgroup 1 tended to be above the population sample means with the largest deviations occurring on the Verbal and Memory/sequencing factors.

Subgroup 2 was composed of nine boys and four girls. Performance far below the sample population mean on the Memory/sequencing factor with other scores close to the mean characterized this subgroup (*low Memory/sequencing*).

Below average performance on the Verbal factor and above average performance on the Auditory sequencing factor characterized the two boys and six girls in Subgroup 3. The sex ratio of this subgroup was opposite to the usual preponderance of boys. Subgroup 3 could be described as *low Verbal and high Auditory sequencing*.

Subgroup 4 was very small, consisting of three boys and one girl. This subgroup was superior to the sample population mean on the Verbal factor but extremely low on the Spatial/visual-motor factor (*low Spatial and high Verbal*).

Subgroup 5 consisted of six boys and three girls and was characterized by poor performance on the Auditory sequencing factor. Performance was near average on the other factors, although the Verbal factor was relatively low (*low Auditory sequencing*).

Significant differences among the subgroups confirmed the subgroup characteristics described above. For example, Subgroup 2 (low Memory/sequencing) was significantly below Subgroups 1, 3 and 5 on the Memory/sequencing factor. Subgroup 5 (low Auditory sequencing) was significantly below all other subgroups on the Auditory sequencing factor, and Subgroup 4 (low Spatial, high Verbal) was below all other subgroups on the Spatial/visual-motor factor. Subgroup 3 (low Verbal, high Auditory sequencing) had higher scores than Subgroups 2 and 5 on the Auditory sequencing factor and lower scores than Subgroups 1 and 4 on the Verbal factor. Subgroup 1 (average performers) had a fairly flat profile across all four factors, and scored significantly higher than at least one subgroup on each factor: higher than Subgroups 2, 3 and 5 on the Verbal factor; higher than Subgroup 5 in Auditory sequencing; higher than Subgroups 3 and 4 on the Spatial/visual-motor factor; and, higher than Subgroups 2 and 4 on the Memory/sequencing factor.

Discriminant function analysis yielded statistical information relevant to the internal validation of the subgroups. The five subgroups were used as the classification standard in the discriminant function analysis of four factor scores. The subject to variable ratio conformed to the requirements for the conservative use of this analysis.

SPSS Program DISCRIMINANT (Nie et al., 1975) yielded four significant canonical discriminant functions which weight test scores to maximize the differences among the subgroups. The first significant discriminant function (Wilks lambda=.0134, df=16, $p<.01$) was characterized by a low loading on the Spatial/visual-motor factor and high positive loadings on the Auditory sequencing, Memory/sequencing and Verbal factors. The second discriminant function (Wilks lambda=.120, df=9, $p<.01$)

involved positive loadings on the Auditory sequencing and Spatial factors, and negative loadings on the Verbal and Memory/sequencing factors. The third discriminant function (Wilks lambda=.304, df=4, $p<.01$) gave high positive loadings to the Spatial and Memory/sequencing factors and a high negative loading to the Auditory sequencing factor. The fourth discriminant function (Wilks lambda=.624, df=1, $p<.01$) gave a high postive weight to the Verbal and Spatial factors and high negative weight to the Memory/sequencing factor.

On the basis of the four significant functions, all 49 subjects were correctly classified in their respective subgroups. Four significant discriminant functions were required to differentiate among the five subgroups. Thus, six graphic plots would be required to plot the subjects against each pair of discriminant functions to provide graphic information relative to the distinctiveness of the subgroups on the classification variables. Graphic data from the discriminant function analysis were not used for the purpose of internal validation.

External Validity of the Cluster Analysis Subgroups Against Nonreading Measures

The subgroups were formed on the basis of factor scores which represented four dimensions tapped by the nonreading battery. To verify the distinctiveness of the subgroups on nonreading measures, univariate analyses of variance and

Scheffe multiple comparisons were computed to determine subgroup differences on the extensive battery of nonreading measures. Means, standard deviations, and F-ratios are included in Appendix L. The results of Scheffe post hoc comparisons are included in Appendix M. There were many significant differences among the subgroups on nonreading measures, thus confirming their distinctiveness in terms of these variables.

Subgroup 1 (average performers) tended to be significantly different from other subgroups on a wide range of variables. Higher IQ scores, particularly on performance measures, characterized Subgroup 1.

Subgroup 2 (low Memory/sequencing) performed at significantly lower levels than Subgroup 1 (average performers) on Grammatic Closure, Trail-making A and Knox immediate and delayed recall. Knox immediate recall was also low compared with Subgroup 5 (low Auditory sequencing) and delayed recall was low compared with Subgroup 3 (low Verbal). Although not all memory and sequencing problems of Subgroup 2 were visual (e.g., Grammatic Closure), this subgroup showed superiority to Subgroup 5 (low Auditory sequencing) on three measures which involved auditory sequential processing, namely, Oral Directions, Word Series accuracy and Model Sentences.

The low Verbal factor performance of Subgroup 3 was confirmed by significantly lower scores on *PPVT-R* compared with Subgroups 1 (average performers) and 4 (low Spatial, high Verbal), and lower VIQ compared with Subgroup 1. Skill in Auditory sequencing was reflected in significantly higher scores on Confrontation Naming compared with Subgroups 4 (low Spatial, high Verbal) and 5 (low Auditory sequencing), on Trail-making B compared with Subgroup 4, and on Digit Span, Sound Blending, Oral Directions and Model Sentences compared with Subgroup 5.

Subgroup 4 (low Spatial, high Verbal) was significantly below all other subgroups on Trail-making B. *BVRT* copying was significantly lower than Subgroup 1 (average performers) and Subgroup 2 (low Memory sequencing). Confrontation Naming was slow compared with Subgroups 1 and 3 (low Verbal, high Auditory sequencing). Knox immediate recall was low compared to Subgroups 1 (average performers) and 5 (low Auditory sequencing. Performance IQ scores were low in contrast to Subgroup 1. High verbal functioning was indicated by significantly higher scores on *PPVT-R* than Subgroups 3 and 5, and on Grammatic Closure compared with Subgroups 2 and 5.

The low Auditory sequencing characteristics of Subgroup 5 were evident in lower scores on Model Sentences compared to all other subgroups, lower scores on Oral Directions than Subgroups 2 (low Memory sequencing), 3 (low Verbal) and 4 (low Spatial, high Verbal) and on Grammatic Closure compared with Subgroups 1 (average performers), 3, and 4. Subgroup 5 had the highest score on Knox immediate recall but was lower than Subgroups 1 and 3 in delayed recall and showed the greatest decrease in recall under the delayed condition. The possible involvement of labeling and verbal rehearsal for delayed recall may have influenced the poor performance by Subgroup 5 which demonstrated deficits on auditory sequencing tasks.

External Validity of the Cluster Analysis Subgroups Against Reading and Spelling Measures

An important aspect of the analysis involved validation of the five subgroups against external reading and spelling data. This validation procedure examined the interface of nonreading and reading and spelling characteristics of disabled readers in response to the research question: Do subgroups of disabled readers identified on the basis of nonreading variables have external validity in terms of reading and spelling characteristics?

Reading and spelling test scores of the five subgroups were compared in oneway analyses of variance. The *F*-ratios, means and standard deviations for these comparisons are included in Appendix N. There were no significant differences in the level of reading proficiency, (*Woodcock* tests), spelling proficiency or phonetic accuracy in spelling. The analyses of variance indicated significant subgroup differences on three oral reading measures: Meaning scale, comprehension of oral reading passages, and the Semantic acceptability scale. Scheffe post hoc comparisons indicated that the oral reading errors of Subgroup 4 (low Spatial, high Verbal) resulted in less meaning change than the errors of Subgroups 1 (average performers) and 3 (low Verbal, high Auditory sequencing). Subgroup 1 (average performers) had significantly higher passage comprehension than Subgroup 3 (low Verbal, high Auditory sequencing). Scheffe post hoc comparisons were not significant for the Semantic acceptability scale on which Subgroup 4 (low Spatial, high Verbal) was highest and Subgroup 1 (average performers) was lowest.

Nonsignificant trends as well as the significant differences among the subgroups were examined to determine the reading and spelling characteristics of the five subgroups. Subgroup 5 (low Auditory sequencing) obtained among the lowest scores on the *Woodcock* tests, together with low scores for Subgroup 4 (low Spatial, high Verbal) on the Word Attack test and for Subgroup 2 (low Memory/sequencing) on the Passage Comprehension test. There were differences in the readability levels of the passages read orally by the five subgroups. Subgroup 3 (low Verbal, high Auditory sequencing) read the most difficult passages, followed by Subgroup 1 (average performers). Subgroup 2 (low Memory/sequencing) read the easiest passages and Subgroups 4 (low Spatial, high Verbal) and 5 (low Auditory sequencing) also read relatively easy passages.

The readability levels of the passages read orally by Subgroup 1 (average performers) were relatively difficult and yet this subgroup had the highest comprehension of the passages. The high oral passage comprehension in contrast to low Syntactic and Semantic acceptability and a high degree of meaning change may be attributable to frequent nonsense word substitutions which were self-corrected to maintain passage comprehension. Thus, Subgroup 1 appeared to use graphic and phonic cues to identify words while also attending to the contextual acceptability of the errors as indicated by frequent self-corrections and good overall passage comprehension. Use of the complex of cues available in connected text was thus found for the largest subgroup of subjects who were relatively proficient on the four nonreading dimensions assessed.

The reading characteristics of Subgroup 2 (low Memory/sequencing) were somewhat similar to those of Subgroup 1 (average performers). However, the passages read orally by Subgroup 2 were less difficult than those read by Subgroup 1. Subgroup 2 was thus composed of less proficient readers than Subgroup 1. Subgroup 2 was similar to Subgroup 1 in the Graphic and Phonic similarity and Syntactic acceptability of oral reading errors and in the degree of meaning change. Subgroup 2 made fewer nonsense word substitutions and achieved higher Semantic acceptability than Subgroup 1. Although self-corrections were also high for Subgroup 2, subjects in this subgroup failed to maintain the high overall oral passage comprehension of Subgroup 1. Thus, Subgroup 2 appeared to use reading strategies similar to those of Subgroup 1 but read easier passages at a similar speed and with less comprehension. These differences may be related to the differences between Subgroups 1 and 2 on the Memory/sequencing and Verbal factors. Lowered comprehension of passages read orally may be associated with less verbal facility and/or difficulties in handling sequential memory tasks.

Subgroup 3 (low Verbal, high Auditory sequencing) was distinct from the other subgroups in several ways. This subgroup read the most difficult passages orally at the highest speed. However, passage comprehension was lowest of all subgroups. Subgroup 3 was characterized by the highest scores on the Graphic and Phonic similarity scales, a relatively low score on the Semantic acceptability scale, and the most meaning change. Subgroup 3 also achieved the highest spelling grade, had a high percent of phonetically accurate spelling errors and had the highest scores on *Woodcock* Word Attack. Thus, Subgroup 3 may be described as relatively proficient in the use of spelling-sound correspondence rules, both in oral reading and in spelling.

Subgroup 3 appeared to approach oral reading as a decoding task with less emphasis upon meaning but did not appear to differ from the other subgroups on the *Woodcock* Passage Comprehension test. It may be that because Subgroup 3 read the most difficult passages orally, these subjects had to rely on graphic and phonic cues rather than contextual cues because the material was of increased difficulty. The difficulty level of the passages read by the subjects in the present study was controlled on the basis of error rate defined as word recognition errors, regardless of the level of comprehension. Thus, subjects who were better in the mechanics of word recognition read more difficult passages to reach the required error rate.

Low use of contextual cues and disregard for meaning were found in Subgroup 3, which was lowest on the Verbal factor. The high scores on two factors involving memory and sequencing dimensions suggest that skills in memory/sequencing are associated with the grasp of spelling-sound correspondence rules.

Subgroup 4 (low Spatial, high Verbal) read easy passages and had the lowest scores on the Graphic and Phonic similarity scales. Scores on the Syntactic and Semantic acceptability scales were high. Oral reading passage comprehension was high and errors resulted in the least meaning change. Subgroup 4 made the most letter order reversals, word order reversals and omissions. Scores were among the highest on *Woodcock* Passage Comprehension but among the lowest on Word Attack. Thus, Subgroup 4 appeared to be more proficient in the use of contextual cues than in the use of grapho-phonic cues. Subgroup 4 was very small with the unusual profile of high verbal abilities and low spatial/visual-motor abilities. The nonreading profile appeared to be related to the reading characteristics of this subgroup in that verbal abilities may encourage use of contextual cues while poor spatial abilities may interfere with learning and using grapho-phonic cues which involve attention to the visual configuration and spelling patterns of written text.

Subgroup 5 (low Auditory sequencing) tended to have low scores on *Woodcock* Word Identification, Word Attack and Passage Comprehension and to have fewest phonetically accurate spelling errors. Subgroup 5 read easy passages slowly, with few self-corrections and poor overall comprehension. Low Word Attack, low phonetic accuracy of spelling errors, slow speed and low Word Identification suggest a relationship between auditory sequencing skills and the speed and accuracy with which spelling-sound correspondence rules are applied. Scores on the qualitative reading scales for Subgroup 5 were similar to those of Subgroup 1 (average performers), but speed and comprehension were lower. Nonsense word substitutions were high for this subgroup. Oral reading errors tended to change passage meaning, although they tended to maintain Syntactic acceptability. The members of this subgroup appeared to use graphic, phonic and syntactic cues in oral reading, but did so slowly and failed to monitor the contextual appropriateness of responses. Few errors were corrected and the uncorrected errors probably contributed to poor passage comprehension. Poor comprehension may be associated with the relatively low Verbal factor score of Subgroup 5.

H. Correspondence among Reading and Nonreading Subgroups

To this point, the interface between reading and nonreading characteristics of subgroups of disabled readers has been examined by determining differences among subgroups on variables external to the measures used to form the subgroups. The interface between reading and nonreading characteristics was also evaluated by comparing the correspondence in subgroup membership across subgroups formed by statistical analyses of the two types of measures. The numbers of subjects placed in various combinations of subgroups by the analyses of the two types of data are presented in Table VII.9.

First, the four subgroups formed by Q factor analysis of 11 reading measures were compared with the five subgroups formed by cluster analysis of four nonreading factors. Few subjects were grouped together in similar ways by the two analyses. Subjects of reading Subgroup 1 (least proficient) were most highly represented in nonreading Subgroups 2 (low Memory/sequencing), 5 (low Auditory sequencing) and 4 (low Spatial, high Verbal). Subjects of reading Subgroup 2 (context cue users, poor comprehenders) were distributed across nonreading Subgroups 1, 2, 3 and 5 and subjects of Subgroup 3 (low grapho-phonic cue users) were classified in nonreading Subgroups 1, 4 and 5. Subjects of reading Subgroup 4 (high comprehenders) showed the highest correspondence to a nonreading subgroup with six subjects classified in nonreading Subgroup 1 (average performers).

TABLE VII.9
CORRESPONDENCE AMONG SUBJECTS CLASSIFIED IN VARIOUS SUBGROUPS BY STATISTICAL CLASSIFICATION OF READING MEASURES AND NON READING MEASURES

			NONREADING SUBGROUPS				
READING SUBGROUPS		n	1 (n=15)	2 (n=13)	3 (n=8)	4 (n=4)	5 (n=9)
Q Factor Analysis Subgroups	1	10	1[1]	4[2]	0	2	3
	2	8	1	3	2	0	2
	3	5	2	0	0	1	2
	4	10	6	2	1	1	0
Cluster Analysis Subgroups	1	11	3	3	1	0	4
	2	12	1	5	2	2	2
	3	13	4	2	5	0	2
	4	13	7	3	0	2	1

1. The number of subjects in Subgroup 1 formed by Q Factor Analysis of reading measures and in Subgroup 1 formed by cluster analysis of nonreading factors.
2. The number of Subjects in Subgroup 1 formed by Q Factor Analysis of reading measures and in Subgroup 2 formed by cluster analysis of nonreading factors.

The four subgroups formed by cluster analysis of 11 reading measures were also compared with the five nonreading subgroups. Subjects of reading Subgroup 1 (least proficient) were classified in nonreading Subgroups 1, 2, 3, and 5, with the greatest correspondence to Subgroup 5 (low Auditory sequencing). Reading Subgroup 2 (context cue users, poor comprehenders) shared the most subjects with nonreading Subgroup 2 (low Memory/sequencing) with the remaining subjects distributed across the four other subgroups. Subjects of reading Subgroup 3 (grapho-phonic cue users) were classified primarily in nonreading Subgroups 1 (average performers) and 3 (low Verbal, high Auditory sequencing). Again, reading Subgroup 4 (high comprehenders) showed the greatest similarity to nonreading Subgroup 1 (average performers) with the two subgroups sharing seven subjects. Overall, 21 subjects (43%) were grouped together in similar ways.

The comparisons of subgroup membership suggested that the interface of reading and nonreading characteristics of disabled readers involves complex relationships. The most consistent relationships appeared to be between high oral reading comprehension and relatively good performance on all nonreading factors, and between grapho-phonic cue use and the Auditory sequencing factor.

VIII. Summary and Conclusions

A major finding of the present study was that disabled readers drawn from a school population could be empirically classified into subgroups on the basis of reading characteristics and on the basis of nonreading characteristics. The results thus support the view that the population of disabled readers is comprised of a number of subgroups, each manifesting different deficiencies in reading and nonreading skills. However, the results indicated that the subgroups into which the disabled readers were classified varied depending upon the variables and statistical procedure selected for the classification analysis, thus emphasizing the importance of evaluating the internal and external validity of the subgroups.

The main purpose of the present study was to examine the interface between reading and nonreading characteristics of disabled readers, addressing the issue of external validity. The results indicated that the interface involves complex relationships. There appears to be a need for caution in inferring relationships between reading and nonreading characteristics of disabled readers in the absence of empirical measurement of both types of characterisitics.

In the present study, more satisfactory classification solutions were obtained on the basis of reading measures than on the basis of nonreading measures. Doehring et al. (1981) also used statistical classification with various types of measures and found the best solution for reading and reading-related measures, a fairly good solution for language measures, and an uninterpretable solution for a nonreading battery of neuropsychological measures.

It may be that reading measures yield better classification solutions than nonreading measures because there are subgroups of disabled readers which are more homogeneous in their reading characteristics than in their nonreading characteristics. Greater heterogeneity of nonreading characteristics would make it difficult to identify homogeneous subgroups on the basis of such characteristics, particularly for small samples. In addition, even though standardized, nonreading measures were based on more diverse scales of measurement than reading measures which may have contributed to the poor classification solutions.

Cluster analysis yielded more satisfactory solutions than Q factor analysis, particularly when applied to nonreading measures. Small sample size and the nature of the standardized scores may have weakened the applicability of Q factor analysis in the present study. The assumption of linearity was questionable. Linear dependence among subjects was apparent for reading measures and may have contributed to the inappropriateness of Q factor analysis in the present study.

However, the failure to identify interpretable subgroups based on Q factor analysis of nonreading measures was in agreement with the findings of Doehring et al. (1981). A major weakness of Q factor analysis in the present study was low coverage, which was also a problem with the Q factor analyses of nonreading measures reported by Fisk and Rourke (1979) and Petrauskas and Rourke (1979).

Overall, the results of the present study confirmed that statistical classification procedures will identify subgroups of disabled readers. More satisfactory results were obtained for cluster analysis over Q factor analysis and for reading measures over nonreading measures. The subgroups formed are discussed in the next two sections. First, results related to identification of subgroups based on reading characteristics will be presented, followed by findings related to the identification of subgroups based on nonreading characteristics.

A. Findings Related to the Identification of Subgroups on the Basis of Reading Measures

The results of the present study provided support for the utility of analyses of oral reading errors in assessing individual differences in the reading strategies of disabled readers. The relative frequency of error types among disabled readers in the present study was similar to the findings of Graham (1980), Hood (1979) and Leslie (1980). In agreement with the findings of Graham (1980), Leslie (1980) and Levy (1977), qualitative analyses of errors indicated that the disabled readers relied most heavily upon graphic and syntactic cues in oral reading and that the majority of errors tended to change the meaning of the passage.

The qualitative analysis of oral reading errors was found to be reliable and sensitive to differences in the use of grapho-phonic cues and contextual cues in the oral reading of connected text. High reliance on grapho-phonic cues appeared to reflect an approach to reading as a decoding task with little attention to meaning. Self-corrections were found to be related to passage comprehension in agreement with the findings of Beebe (1980).

The present study permitted a limited evaluation of the relationship between reading and spelling among disabled readers. Spelling achievement tended to be low among the disabled readers. Overall, half of the spelling errors of the disabled readers were phonetically accurate. Although phonetic accuracy in spelling was related to word attack skills, there were no differences in the reading characteristics of phonetically accurate and phonetically inaccurate spellers. These findings argue against using spelling errors to form subgroups of disabled readers which are assumed to differ in reading characteristics (e.g., Boder, 1973). However, the spelling assessment used in the present study was limited: items were not selected on the basis of the sight vocabulary of individual subjects and the phonetic regularity and irregularity of the words were not controlled.

Q factor analysis and cluster analysis of 11 reading measures shared a core of subjects who were placed in similar subgroups. Both statistical procedures formed a subgroup characterized by the slowest and least proficient word identification (Subgroup 1), a subgroup characterized by high use of contextual cues but low comprehension (Subgroup 2), and a subgroup characterized by high comprehension (Subgroup 4). A subgroup characterized by low use of grapho-phonic cues was identified by Q factor analysis, whereas high grapho-phonic cue use characterized Subgroup 3 of the cluster analysis. Although three subgroups of each analysis were similar in their main identifying characteristics, subgroup membership was not identical across the two statistical procedures and the characteristics of the subgroups will be discussed separately. The subgroups formed by Q factor analysis of 11 reading measures will be discussed first, followed by the cluster analysis subgroups.

Reading Subgroups Formed by Q Factor Analysis

Subgroup 1 (least proficient) formed by Q factor analysis of reading measures was characterized by the lowest level of reading achievement and poorly developed component skills for automatic word identification. Extremely slow oral reading, high self-corrections and striving for meaning characterized this subgroup. Nonreading characteristics included mixed deficits involving cognitive, linguistic and perceptual skills.

Subgroup 1 resembled Boder's (1973) mixed dysphonetic-dyseidetic subgroup in that the readers were the most severely disabled and had deficits in both the auditory and visual modalities. The bizarre spelling errors of Boder's mixed subgroup were not characteristic of Subgroup 1. Anomia (poor naming) plus poor comprehension of oral directions were characteristic of Subgroup 1 and of Mattis et al.'s (1975) language disorder. However, Subgroup 1 was not a pure language disorder and had additional deficits in visual-motor functioning.

Subgroup 2 (context cue users, poor comprehenders) formed by Q factor analysis appeared to be comprised of relatively proficient readers who used contextual cues for word identification at a fast rate on passages of relatively high readability. However, this subgroup had poor comprehension despite the development of component word identification skills. Nonreading deficits involved linguistic skills whereas this subgroup had strength in visual-motor functioning. Good performance on several language measures indicated that this subgroup did not have an overall comprehension disorder.

Anomia plus poor auditory discrimination were characteristic of Subgroup 2 and of the language disorder subgroup of Mattis et al. (1975). The pattern of better word identification and poor comprehension resembled Myklebust's (1978) inner language dyslexia. The global language subgroup of Satz and Morris (1980) was also low on Similarities, *PPVT* and fluency (Word Associations).

Subgroup 3 (low grapho-phonic cue users) was a small subgroup unique to the Q factor analysis procedure and was characterized by slow oral reading and low graphic and phonic similarity of oral reading errors. The greatest difficulty appeared to be in quickly applying component skills in the oral reading of connected text. Nonreading deficits included poor performance on measures of lower level linguistic skills, particularly those involving speech production, as well as on a visual-motor copying task.

The poor use of grapho-phonic cues as well as difficulty on tasks involving speech production suggested similarity to the articulatory and graphomotor dyscoordination disorder reported by Mattis et al. (1975). However, Subgroup 3 had some phonic attack skills as measured by the *Woodcock* in contrast to the lack of phonic attack skills for the Mattis et al. subgroup. Anomia and poor sentence repetition suggested a resemblance between Subgroup 3 and Mattis et al.'s (1975) language disorder or Mattis' (1978) interpretation of Denckla's (1977) dysphonemic-sequencing disorder characterized by poor Digit Span and sentence repetition.

Subgroup 4 (high comprehenders) was characterized by fast oral reading and high comprehension. However, knowledge of spelling-sound correspondence rules was not well-developed. This subgroup was least impaired of all subgroups on the nonreading measures with evidence of difficulty in Auditory Discrimination in contrast to strength on a number of language and sequencing tasks.

The overall good performance of Subgroup 4 suggested a resemblance to Lyon and Watson's (1981) Subgroup 6 which had a normal diagnostic profile, and to the unexpected subgroup of Satz and Morris (1980). However, Word Series and Confrontation Naming were impaired for Subgroup 1 suggesting greater resemblance to Denckla's (1977) pure anomia. The difficulty in using spelling-sound correspondence rules in word identification and in spelling appeared to be similar to the phonetically inaccurate spelling which characterized Boder's (1973) dysphonetic subgroup.

Correspondence between the subgroups formed by Q factor analysis of reading measures and subgroups previously reported in the literature was not high. The deficits in Word Series, Confontation Naming and finger localization (dominant hand) for all subgroups, and Digit Span deficits for all but Subgroup 4 resulted in most subgroups resembling Mattis et al.'s (1975) language disorder subgroup in some way. Subgroup 1 (least proficient) appeared to have mixed deficits. Subgroup 2 (context cue users, poor comprehenders) appeared to be primarily a language disorder. Subgroup 3 (low grapho-phonic cue users) appeared to have more specific deficits in sequencing and in motor speech movement. Subgroup 4 (high comprehenders) appeared to have mild dysphonetic characteristics.

Reading Subgroups Formed by Cluster Analysis

Subgroup 1 (least proficient) formed by cluster analysis of 11 reading measures was characterized by the least proficient and slowest word identification. This subgroup appeared to be striving for meaning during oral reading and attempted to use both grapho-phonic and contextual cues, but was slow in using these cues for word identification. Nonreading characteristics involved difficulty on tasks requiring speed and/or sequential processing.

Subgroup 1's deficits on Digit Span, naming and sentence repetition resembled Denckla's (1977) anomia plus repetition disorder or Mattis et al.'s (1975) language disorder. Deficits on Digit Span, Coding and sentence repetition together with a minimal VIQ-PIQ split and finger localization errors (nondominant hand) of Subgroup 1 were similar to the deficits of Petrauskas and Rourke's (1979) Type 2 sequencing disorder. Subgroup 1 was similar to Doehring et al.'s (1981) Type S sequencing disorder in that both subgroups had a short Digit Span and finger localization difficulties. However, Subgroup 1 did not appear to have the spatial deficits of the Type S sequencing disorder.

Subgroup 2 (context cue users, poor comprehenders) read relatively quickly and appeared to rely upon contextual cues to identify words during oral reading, but did not monitor for overall comprehension. Low scores on VIQ measures, particularly Similarities, appeared to be related to the poor comprehension. However, absence of difficulty on several language measures provided evidence that there was no generalized comprehension disorder. Other low scores suggested difficulty in sequencing, although less generalized than the sequencing difficulties of Subgroup 1 (least proficient).

Relatively low phonetic accuracy of spelling errors and the use of contextual cues suggested similarity to Boder's (1973) dysphonetic subgroup. However, Subgroup 2 showed greater skill in phonetic analysis than the dysphonetic subgroup. Subgroup 2's deficits in naming and Digit Span resembled Denckla's (1977) anomia plus repetition disorder. Poor comprehension in relation to word identification skill resembled Myklebust's (1978) inner language dyslexia.

Subgroup 3 (grapho-phonic cue users) showed relative proficiency in the use of spelling-sound correspondence rules in reading and spelling, but had low oral passage comprehension. This subgroup was characterized by higher performance IQ scores and lower verbal IQ scores, and had the largest low VIQ-high PIQ split. Subgroup 3 demonstrated relative strengths on measures of memory and sequencing in both the auditory and visual modalities.

Subgroup 3 resembled Boder's (1973) dyseidetic subgroup, sharing reliance on phonetic analysis in reading and spelling. Relative proficiency in decoding over comprehension resembled Myklebust's (1978) inner language dyslexia. Low scores on Similarities and *PPVT* resembled Satz and Morris' (1980) global language subgroup, although fluency was not impaired for Subgroup 3.

Subgroup 4 (high comprehenders) was characterized by relatively high comprehension and low use of grapho-phonic cues in oral reading. This subgroup tended to be least impaired on IQ measures, with the exception of Arithmetic, Digit Span and Coding. Strengths in higher level linguistic skills were apparent, while lower level linguistic skills measured by Word Series and Confrontation Naming were weak.

The low phonetic accuracy in spelling and low grapho-phonic cue use of Subgroup 4 suggested a resemblance to Boder's (1973) dysphonetic subgroup, although Subgroup 4 may have greater skill in phonetic analysis. Again, deficits in Digit Span and naming resembled Denckla's (1977) anomia plus repetition disorder.

The four subgroups formed by cluster analysis of reading measures all showed deficits in low level linguistic skills, i.e., Word Series and Confrontation Naming. All but Subgroup 3 were impaired on Digit Span. Thus, several subgroups resembled Denckla's (1977) anomia plus repetition disorder. Subgroup 1 (least proficient) appeared to be primarily a sequencing disorder. Subgroup 2 (context cue users, poor comprehenders) appeared to have milder sequencing deficits as well as linguistic deficits. Subgroup 3 (grapho-phonic cue users) appeared to be a mixed linguistic disorder. Subgroup 4 (high comprehenders) appeared to be a low level linguistic disorder.

B. Findings Related to the Identification of Subgroups Based on Nonreading Measures

The pattern of strengths and deficits on nonreading measures based on the average performance levels of the total sample was consistent with previous research findings. In summary, motor performance, Performance IQ, visual sequencing and higher level linguistic skills were least impaired. Verbal IQ, lower level linguistic skills, auditory sequencing and finger localization were most impaired.

Performance IQ test scores tended to be at higher levels than Verbal IQ test scores, with the lowest scores on Information, Arithmetic, Digit Span and Coding. This pattern has been reported frequently among learning disabled children and has been described as the *ACID* pattern (Kaufman, 1979a, 1979b, 1981; Lutey, 1977; Moore & Wielan, 1981). Excluding Information, these tests comprise Bannatyne's (1974) Sequencing pattern and Kaufman's (1975) Freedom from Distractibility pattern.

A large proportion of subjects showed a verbal decrement with a low VIQ-high PIQ split, while few subjects had a high VIQ-low PIQ split. These findings are in agreement with those of Warrington (1967) and Nelson and Warrington (1974).

Subjects in the present study experienced considerable difficulty on language tests. Low level phonological tasks requiring rapid speech production were most impaired. The widespread difficulty in Confrontation Naming is consistent with the findings of Denckla and Rudel (1976). Poor performance by disabled readers in the rapid reproduction of series of words (e.g., naming months) has also been reported by Doehring et al. (1981). The involvement of speech on the tasks which were most impaired for the present sample of disabled readers may be of critical importance. Rudel, Denckla and Broman (1978) suggested that there may be a specific relationship of reading to speech or to the greater mobilization of language functions which speech requires.

There was also evidence of impairment on higher level linguistic skills among subjects in the present study, although syntactic and semantic processing difficulties were less widespread than the lower level linguistic difficulties. Many subjects experienced difficulty in the production and reception of syntactic structures, in agreement with the findings of Vogel (1974).

There was considerable variability in the language test performance of the present sample. Although linguistic deficits were prevalent, generalized language impairment did not characterize all disabled readers. Doehring et al. (1981) also reported variability in language test performance among disabled readers.

The well-developed visual attention span and poor auditory sequential memory of the present sample was similar to the pattern of performance of disabled readers reported by Doehring et al. (1981). Verbal sequential processing difficulties were evident for large numbers of subjects on several language tests.

Motor performance was average for the present sample. Right-left discrimination and finger localization were performed poorly by many subjects. A relationship between difficulty in finger localization and reading problems has been reported by others (e.g., Benton, 1975; DeHirsch, Jansky & Langford, 1966; Doehring et al., 1981; Satz, Taylor, Friel & Fletcher, 1978).

As a group, the subjects in the present sample could not be described as a behaviour problem or hyperactive group. There was considerable variability in classroom behaviour with Inattentive-Passive behaviour reported most frequently by teachers.

There was an overall lack of sex differences in the present study. Teachers rated boys significantly more poorly than girls on scales assessing Conduct Problems and Hyperactivity. The only significant sex difference in test performance involved Verbal IQ (Information) and favored the boys. This finding is in agreement with those of Canning, Orr and Rourke (1980) who found only one significant difference between reading disabled boys and girls. This difference also involved a language measure (*PPVT*) and favored the boys.

The variability in performance among the disabled readers on the nonreading measures provided evidence that disabled readers are not homogeneous in nonreading characteristics. However, the identification of subgroups using statistical classification procedures and nonreading measures was not highly successful in the present study, as will be discussed in the next section.

Nonreading Subgroups Formed by Cluster Analysis

Five subgroups were formed by cluster analysis of four nonreading factors. Subgroup 1 (average performers) was at or above the sample population mean on all four nonreading factors indicating relative proficiency in linguistic, sequencing and perceptual skills. This subgroup appeared to use the complex of cues available in reading connected text.

The general absence of impairment on nonreading measures suggested that Subgroup 1 was similar to the unexpected subgroup of Satz and Morris (1980) and the normal profile Subgroup 6 of Lyon and Watson (1981), both of which were free of impairment on the skills assessed. However, as with the other four nonreading subgroups, Subgroup 1 performed at low levels on the Confrontation Naming and Word Series tests. The naming difficulty in the absence of other deficits resembled Denckla's (1977) pure anomia.

Subgroup 2 was low on the Memory/sequencing factor and relatively low on the Verbal factor. This subgroup appeared to use the complex of cues available to identify words in connected text, but read easy passages with poor comprehension. Nonreading deficits included low VIQ and

Grammatic Closure, and poor performance on auditory and, particularly, visual sequencing tasks.

Deficits in naming and Digit Span resembled Denckla's (1977) anomia plus repetition disorder. The visual memory and sequencing problems and specific verbal deficits suggested a mixed disorder, although unlike those described previously in the literature.

Low use of contextual cues and little attention to the meaning of what was being read were found for Subgroup 3, which was lowest on the Verbal factor and high on the Auditory sequencing factor. The use of context and monitoring for meaning thus appeared to be related to higher level linguistic skills rather than to lower level auditory sequencing skills. Subgroup 3 showed the greatest facility in using spelling-sound correspondence rules in reading and spelling in conjunction with high scores on the Auditory sequencing and Memory/sequencing factors pointing to a relationship between memory and sequencing skills and the grasp of spelling-sound correspondence rules. This subgroup was unusual in its sex distribution, consisting of six girls and two boys. Thus, although there were few sex differences in the present study, sex may be important in differentiating among some subgroups of disabled readers.

The phonetic analysis skills of Subgroup 3 resembled Boder's (1973) dyseidetic dyslexia. The relatively high decoding skills and low comprehension skills of Subgroup 3 were similar to Myklebust's (1978) inner language dyslexia.

Subgroup 4 was small and had high verbal abilities but low visual/spatial abilities. The high verbal skills may have contributed to the reliance on contextual cues in reading connected text observed for Subgroup 4. Poor spatial abilities may have contributed to the low use of grapho-phonic cues, the frequency of letter and word order reversals and omissions which suggested limited attention to the visual configuration and spelling patterns of written text.

This small subgroup confirmed the existence of the unusual profile of visuoperceptive deficits among a small number of disabled readers. This subgroup was comparable to the visuospatial perceptual disorder (Denckla, 1977; Mattis et al., 1975), the visual-perceptual motor subgroup (Satz & Morris, 1980) and Lyon and Watson's (1981) Subgroup 4.

Low scores on measures of word attack, phonetic accuracy of spelling errors, oral reading speed and word identification obtained by Subgroup 5 (low Auditory sequencing) suggested a relationship between auditory sequencing skills and the efficient application of spelling-sound correspondence rules. Poor passage comprehension together with relatively low performance on both the Verbal factor and the Auditory sequencing factor suggested that comprehension was related to linguistic skills.

Subgroup 5's deficits in naming, repetition and comprehension of oral directions resembled Denckla's (1977) mixed language subgroup and Mattis et al.'s (1975) language disorder. Low VIQ-high PIQ, poor comprehension of oral directions and poor sentence repetition also characterized Petrauskas and Rourke's (1979) Type B conceptual flexibility subgroup.

The interface between reading and nonreading characteristics of the five nonreading subgroups indicated complex relationships, particularly between reading comprehension and linguistic skills and between the grasp of spelling-sound correspondence rules and sequencing skills. Although all subgroups had low level linguistic deficits, better comprehension tended to be associated with higher performance on the Verbal factor. Auditory sequencing skills appeared to be related to the speed of oral reading and the use of spelling-sound correspondence rules.

C. Findings Related to the Interface of Reading and Nonreading Characteristics

The low correspondence of subjects across reading and nonreading subgroups indicated that the patterns of reading test characteristics defining subgroups did not correspond directly and simply to patterns of nonreading test performance which defined other subgroups. The most consistent correspondence appeared to be between high comprehenders (Reading Subgroup 4) and average performers

(Nonreading Subgroup 1). The Auditory sequencing factor appeared to be related to proficiency in word identification: the least proficient readers corresponded most highly to Subgroup 5 (low Auditory sequencing) while the grapho-phonic cue users who were relatively proficient in using spelling-sound correspondence rules corresponded most highly to Subgroup 3 (low Verbal, high Auditory sequencing).

Consistent relationships among reading and nonreading variables across the subgroups formed by three classification analyses were examined. The four subgroups formed by Q factor analysis of 11 reading measures will be referred to as *QR*, along with the number of the subgroup (e.g., *QR1*). The four subgroups formed by cluster analysis of reading measures will be designated *CLR*, and the five nonreading subgroups formed by cluster analysis of nonreading factors will be *CLN*.

Similarities were noted among subgroups *QR1* (least proficient), *CLR1* (least proficient) and *CLN5* (low Auditory/sequencing). These subgroups appeared to be comprised of the least proficient readers indicated by low levels of performance on the *Woodcock* tests and the low readability of the passages read orally. Slow oral reading speed and low spelling achievement also characterized these subgroups. The severe reading deficits were associated with low VIQ, low Grammatic Closure, low Digit Span and slow Confrontation Naming. Linguistic problems, including anomia and syntactic difficulty, and auditory serial memory deficits thus appeared to be associated with severe deficits in several aspects of reading, including word identification, word attack and speed of oral reading.

QR4 (high comprehenders), *CLR4* (high comprehenders) and *CLN1* (average performers) shared similarities in reading and nonreading characteristics. All subgroups had relatively good comprehension of difficult oral reading passages which were read with relatively good speed. All three subgroups had among the highest levels of VIQ and PIQ, the highest scores on *PPVT-R* and fast performance on Trail-making B. Thus, strengths in cognitive, linguistic and visual perceptual functioning appeared to contribute to the development of strategies for comprehending written text.

The remaining subgroups showed fewer similarities in reading and nonreading performance. However, within each subgroup there appeared to be relationships among these characteristics.

D. Conclusions Related to the Specific Questions of Interest in the Present Study

Question 1: Can internally valid subgroups of disabled readers be identified on the basis of reading characteristics using objective statistical classification procedures?

The results of the present study confirmed that disabled readers drawn from a school population could be empirically classified into subgroups on the basis of reading measures. Sixty-seven percent of the 49 subjects were classified in four subgroups by Q factor analysis while all subjects were classified in four subgroups by Ward's hierarchical cluster analysis followed by an iterative relocation procedure. Cluster analysis thus had higher coverage than Q factor analysis. The subgroups formed by cluster analysis had greater stability than the Q factor analysis subgroups under data manipulation which involved the addition of reading and spelling variables to the analyses. Graphic presentations demonstrated the distinctiveness of all subgroups across the classification variables and thus supported their internal validity. Statistical measures of internal validity evaluating the distinctiveness of the subgroups on the classification variables provided greater support for the internal validity of the cluster analysis subgroups than for the Q factor analysis subgroups.

The cluster analysis solution was preferred over the Q factor analysis solution because it had greater coverage and stronger evidence of internal validity. In contrast, Doehring et al. (1981) preferred Q factor analysis over cluster analysis in deriving subgroups on the basis of reading and reading-related skills for a clinic sample of disabled readers. In the present study, the assumption of linearity was questionable and the subject:variable ratio was high. These factors may have limited the appropriateness of Q factor analysis (Satz & Morris, 1980) and contributed to the better solution found with cluster analysis which is more robust in the presence of departure from linearity (Lyon, in press).

Question 2: Do subgroups of disabled readers identified on the basis of reading characteristics have external validity (a) against reading and spelling measures, and (b) against nonreading measures?

(a) Cluster analysis subgroups showed greater external validity than Q factor analysis subgroups when evaluated against reading and spelling measures external to the classification measures. The cluster analysis subgroups differed significantly on six of 12 measures whereas the Q factor analysis subgroups differed significantly on only three of these measures. The smaller sizes of the Q factor analysis subgroups may have contributed to the few significant differences as large differences are required to reach significance with small subgroups.

(b) When evaluated against external nonreading measures, the external validity of subgroups formed on the basis of reading measures received weak statistical support. The four subgroups formed by Q factor analysis differed significantly on Coding, *BVRT* copying and Tension-Anxiety as rated by teachers. The four subgroups formed by cluster analysis differed significantly on Similarities, Coding, Trail-making A and Finger tapping (dominant hand). The small sizes of the subgroups may have contributed to the failure to find strong statistical support for the external validity of the subgroups. Nonsignificant trends pointed to a complex relationship between the reading and nonreading characteristics of these subgroups.

Question 3: Can internally valid subgroups of disabled readers be identified on the basis of nonreading characteristcs using objective statistical classification procedures?

Q factor analysis of nonreading measures failed to identify internally valid subgroups. Q factor analysis solutions had low coverage, double positive loadings, high negative loadings and were highly variable for different groups of nonreading measures. These findings were in agreement with Doehring et al. (1981) who reported that interpretable subgroups of disabled readers were not identified by Q factor analysis of a large battery of neuropsychological measures. Q factor analyses of nonreading measures also had low coverage in studies by Fisk and Rourke (1979) and Petrauskas and Rourke (1979). Q factor analysis was limited in the present study by the small sample size, the high subject:variable ratio and the questionable assumption of linearity.

Cluster analysis is more robust than Q factor analysis and the assumption of linearity is not as important (Lyon, in press). Cluster analyses of nonreading measures identified subgroups of disabled readers in the present study. The internal validity of the subgroups was not strongly supported by data manipulation which indicated considerable instability of the subgroups identified. However, discriminant function analysis and analyses of variance indicated that five subgroups formed by cluster analysis of four factor scores were distinctive across the four dimensions used in the classification: Verbal, Auditory sequencing, Visual-motor/spatial and Memory/sequencing.

Question 4: Do subgroups of disabled readers identified on the basis of nonreading characteristics have external validity (a) against nonreading measures external to the classification measures, and (b) against reading and spelling measures?

(a) The subgroups formed by cluster analysis differed significantly on many measures of the nonreading battery. External validity against nonreading measures was thus supported.

(b) There was weak statistical support for the external validity of the cluster analysis subgroups evaluated against reading and spelling measures. However, there were trends which suggested relationships between reading and nonreading characteristics of the subgroups. The subgroups differed significantly on oral reading measures of comprehension and the Meaning scale. Post hoc comparisons did not reach significance for the Semantic acceptability scale. The small sizes of the subgroups may have contributed to the few significant differences and weak support for external validity. When nonsignificant trends were considered as well, differences in nonreading characteristics appeared to be related to differences in reading and spelling characteristics.

Question 5: Are there systematic relationships between reading characteristics and nonreading characteristics of disabled readers?

The correspondence between subgroups formed on the basis of the two kinds of data was low. Thus, reading subgroups did not interface simply with nonreading subgroups. There was no direct association between the patterns of reading characteristics identifying subgroups and the patterns of nonreading characteristics which identified other subgroups. These findings were in agreement with Doehring et al. (1981) who reported that the relationship appears to be a complex interaction.

The present study provided support for the view that there are subgroups of disabled readers which differ in reading and nonreading characteristics. Reading subgroups did differ on some nonreading measures which, together with nonsignificant differences, appeared to be related to differences in reading characteristics among the subgroups. Conversely, nonreading subgroups were found to differ on reading measures which appeared to be related to differences on nonreading measures.

E. Recommendations

The writer recommends caution in inferring patterns of nonreading characteristics on the basis of observed patterns of reading characteristics and conversely, in inferring reading characteristics based on observed patterns of nonreading behaviour. The relationships are complex and ill-defined at present.

The writer recommends continued research which systematically compares and evaluates classification procedures. As yet, such procedures cannot be applied with confidence. Classification studies should include evaluation of coverage, internal validity and external validity.

In view of the findings of the present investigation, the author would recommend a replication of the study with several changes:

(a) Sample size should be increased to increase the stability of statistical procedures and to permit cross-validation across subsamples.

(b) Characteristics of the sample should be changed. A wider range of reading deficits, particularly of severe deficits, in word recognition and/or reading comprehension should be included. Large numbers of boys and girls should be included to permit sex comparisons. Several age ranges should be included to allow evaluation of possible developmental differences in the patterns of reading and nonreading characteristics of subgroups. A clinic sample might be included to evaluate the possibility that subgroups of disabled readers may be more clearly defined within a clinic sample than within a public school sample.

(c) A large sample of normal readers should be included so that test means and standard deviations of the normal sample could be used to calculate standard scores for the reading disabled sample. R factor analysis of the nonreading test performance of the normal sample could yield factor loadings to be applied to the scores of the disabled readers to yield factor scores which reflect the nonreading dimensions assessed. Data from the normal sample could be used to facilitate interpretation of the profiles of the disabled readers which could be compared to the average test performance of a sample of normal readers.

(d) Changes in the reading and spelling test battery should be considered. More precise measures of comprehension should be included. Inclusion of both instructional and frustration level passages for oral reading analysis would permit assessment of the flexibility of reading strategies among subgroups of disabled readers. A spelling test which contains equal numbers of phonetically regular and irregular words equated for length and familiarity would improve the qualitative assessment of spelling errors.

(e) Changes to the nonreading battery would include a standardized test of arithmetic achievement and measures which have strong construct validity.

(f) A questionnaire should be completed by classroom teachers, resource room teachers and special class teachers to provide information about the curriculum, reading materials, reading skills and strategies being emphasized at the time of testing. This information could be used to evaluate the possible influence of classroom experience on the strategies used in oral reading.

It is recommended that responses to remedial strategies be evaluated for subgroups identified in classification studies. Differential responses by the subgroups to remedial programs would provide crucial support for the validity of the subgroups and the utility of the classification system for research and treatment.

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APPENDIX A

Operational Definitions Of Error Categories

APPENDIX A: Operational Definitions Of Error Categories[1]

OMISSION:
An omission of one or more text words.

INSERTION:
An insertion of one or more words between two text words.

WORD ORDER REVERSAL:
Word order changes (e.g., put the tent up/*put up the tent*).[2]

LETTER ORDER REVERSAL:
Substitution of a word containing the same letters as the text word but in a different order (e.g. barn/*bran*).

SUBSTITUTIONS:

Same Stem:
Substitution of a word containing the same stem as the text word (e.g., walking/*walked*).

Same Affix:
Substitution of a word containing the same affix as the text word (e.g., unkind/*unkempt*, hopped/*jumped*).

Other Meaningful:
Substitution of a meaningful word if the substitution cannot be categorized as *same stem, same affix* or *letter order reversal*.

Nonsense:
Substitution of a part of a word or a nonsense word (e.g. pra-/pride, strampled/stumbled).

TOTAL ERROR SCORE:
Sum of the above categories.

ADDITIONAL ERROR CATEGORIES:

Repetition:

Repetition of one or more words.

Self-Correction:

Spontaneous successful self-correction of an error.

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1. The definitions are adapted from Hood (1975).
2. The error precedes the diagonal line and the related text is in italics.

APPENDIX B

Description Of Tests

APPENDIX B: Description Of Tests

I. ACADEMIC ASSESSMENT

A. READING

Woodcock Reading Mastery Tests (Form A) (Woodcock, 1973):

Word Identification:

The child is required to identify words presented in context-free lists. Requirement: Sight vocabulary. Score: Achievement Index.

Word Attack:

The child is required to pronounce nonsense words ranging in length from one syllable to five syllables. Requirement: Word attack skills, i.e., phonic and structural analysis skills. Score: Achievement Index.

Passage Comprehension:

A cloze procedure is used. The child is required to silently read sentences from which a word has been deleted and to respond with the missing word. Requirements: Comprehension of connected text. Score: Achievement Index.

B. SPELLING

Edmonton Spelling Ability Test:

The child is required to spell words (written response) of increasing difficulty. Each word is repeated twice and is also presented in sentence context. Requirement: Written spelling of regular and irregular words. Score: Grade level equivalent.

(Note: The phonetic accuracy of the syllables of the words was also analyzed).

II. NONREADING ASSESSMENT

A. INTELLECTUAL

Wechsler Intelligence Scale for Children-Revised[1] (WISC-R) (Wechsler, 1974):[1]

Verbal Tests:[1]

Information: The child is required to answer questions tapping information acquired as a result of native ability and early cultural experience. Requirement: Range of knowledge and long-range memory.

Comprehension: The child is required to answer questions dealing with situations including the body, interpersonal relations and societal activities. Requirement: Social judgement, social conventionality or common sense and the meaningful and emotionally relevant use of facts.

Arithmetic: The child is required to solve orally presented problems involving the use of standard arithmentic operations - addition, subtraction, multiplication and division. Requirement: Reasoning ability, numerical accuracy in mental arithmetic, concentration, attention and memory.

Similarities: The child is required to articulate the basis on which a pair of objects or concepts are related. Requirement: Verbal concept formation and logical thinking.

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[1] The descriptions are taken from Sattler (1974). Scale scores were used for each subtest.

Vocabulary: The child is required to articulate the meaning of words. Requirement: Learning ability, fund of information, richness of ideas, memory, concept formation and language development.

Digit Span: The child is required to repeat series of numbers of increasing length. The repetition of Digits Forward and of Digits Backward are included. Requirement: Attention and short term memory.

Performance Tests:

Picture Completion: The child is required to discover what is missing in each of 20 drawings within a 15-second time limit. Requirement: The ability to differentiate essential from nonessential details, concentration, reasoning and visual organization.

Picture Arrangement: The child is required to arrange a series of pictures into a meaningful sequence. Credit is given for speed. Requirement: Interpretation of social situations, nonverbal reasoning ability and planning ability.

Block Design: The child is required to arrange red and white surfaced blocks to produce designs shown on cards. Credit is given for speed. Requirement: Visual-motor coordination, perceptual organization, spatial visualization, abstract conceptualizing ability and analysis and synthesis.

Object Assembly: The child is required to complete four jigsaw puzzles. Credit is given for speed. Requirement: Visual-motor coordination and perceptual organization ability.

Coding: In Coding B (age 8 and over), the child is required to write symbols shown in a sample in boxes that contain a number in the upper part and an empty space in the lower part. Requirement: Visual-motor coordination, speed of mental operation and short term memory.

B. LANGUAGE

Peabody Picture Vocabulary Test-Revised (PPVT-R) (Dunn & Dunn, 1981) (Form M):

The child is required to choose one of four line drawings which is most appropriately related to a word spoken by the examiner. The test booklet contains 175 sets of drawings associated with words of increasing difficulty. Requirement: Associating a visual picture with a spoken word; receptive vocabulary; semantic reception. Score: Standard score.

Illinois Test of Psycholinguistic Abilities (ITPA) (Kirk, McCarthy & Kirk, 1968):

Grammatic Closure:

Thirty-three orally presented items are accompanied by pictures which portray the content of the verbal expressions. The child is required to finish an incomplete statement about the picture. Requirement: The ability to use the redundancies of oral language for handling syntax and grammar; expressive syntax. Score: Scale score.

Sound Blending:

The child is required to tell what a word is when the sounds of the word are spoken singly at half-second intervals. Requirement: Synthesizing the separate parts of a word to produce an integrated whole; phonemic synthesis. Score: Scale score.

Clinical Evaluation of Language Functions (CELF) (Semel & Wiig, 1980):

#1: Processing Word and Sentence Structures:

The child is required to choose one of four pictures which provides an accurate pictorial representation of the meaning of a stimulus sentence spoken by the examiner. Each distractor picture features a minimal grammatical contrast which influences the meaning. Requirement: Processing and interpreting selected word and sentence structures; syntactical processing. Score: Percent correct.

#4: Processing Relationships and Ambiguities:

The child is required to respond "yes" if a statement is true and "no" if it is false. The 32 statements are logico-grammatical and ambiguous statements which contain comparative, passive, temporal-sequential, familial and analagous relationships, and idioms and metaphors, and proverbs. Requirement: Processing and interpreting logico-grammatical and ambiguous sentences; semantic and syntactic processing and memory. Score: Percent correct.

#5: Processing Oral Directions:

The child is shown stimulus arrays of shapes varying in colour and size and is required to point to the stimuli executing oral commands of increasing length and complexity. Requirement: Interpretation, recall and execution of oral commands of increasing length and complexity. The aspects of language processing assessed include the retention and recall of verbal directions of increasing length; the analysis, synthesis and recall of adjective sequences of increasing length; the interpretation and recall of serial position; and the interpretation and recall of left-right spatial orientation. Score: Percent correct.

#7: Producing Word Series:

The child is required to recite the names of the days of the week and the names of the months of the year as quickly as possible. Requirement: Accurate, fluent and quick recall and production of automatic-sequential word series; semantic production. Score: Accuracy (% correct) and speed (number of seconds) summed over the two series.

#8: Producing Names on Confrontation:

The child is required to name as quickly as possible three sets of items: colours, forms and colour-form combinations. Requirement: Accuracy, fluency and speed in naming stimuli on confrontation; difficulties may indicate word-finding problems (dysnomia) and/or retrieval problems and speed may indicate articulatory-motor functions. Score: Accuracy (% correct) and speed (number of seconds):

#9: Producing Word Associations:

The child is required to say names of as many foods as possible within 60 seconds, and then of animals in another 60 second period. Requirement: Fluency and flexibility in identifying and retrieving members of a semantic class, speed of identification and retrieval of semantically related words and the use of associative grouping strategies in word identification and retrieval; semantic production and recall. Score: Total number correct summed over the two categories.

#10: Producing Model Sentences:

The child is required to repeat sentences of increasing length and complexity. Twenty-three sentences are structurally and semantically acceptable; seven sentences violate syntactic structure or semantic consistency. Requirement: Retention and recall of sentence structure; probes adherence to word meaning and predictability in immediate sentence recall. Score: Percent correct.

#12: Processing Speech Sounds:

The child is required to decide if two words spoken by the examiner are the same or different. Sixty word pairs are presented (29 same; 31 differ by one phoneme). Initial and final consonants, consonant blends, vowels and dipthongs are represented. Requirement: Discrimination between speech sounds (phonemes) in minimally different word pairs; phonological processing. Score: Percent correct.

C. MEMORY/SEQUENCING

WISC-R Digit Span: see description given above.

CELF #5, #7, #9, #10: see descriptions given above.

Knox Cube Test (Arthur, 1947):

The examiner touches a series of four wooden blocks in a certain order and the child is required to touch the blocks in the same order. Two administrations are given, the second administration being an adaptation from Corkin (1974). In the first administration, the child is required to recall the sequence immediately. In the second administration, a ten-second delay is introduced. Requirement: Immediate and delayed recall of visual nonverbal sequences (note: the delayed condition may involve rehearsal strategies). Score: The number correct under immediate recall, the number correct under delayed recall, and a Mental Age Score conversion of the immediate recall score.

Benton Visual Retention Test (BVRT) (Benton, 1963):

Administration C:

The child is required to copy two single figures and seven three figrue designs. Requirement: Visual-motor integration. Score: Number correct and the number of errors summed across the designs.

Trail-making Test (Reitan, 1958):

Form A:

The child is required to connect by a pencil line 15 numbered circles in the correct sequence. Requirement: Sequential identification of numbers and rapid coordination of visual identification with a simple motor response; visual scanning; sequential processing. Score: Time required to correctly complete the sequence.

Form B:

The child is required to connect by a pencil line 15 circles containing the numbers 1 to 8 and the letters A to G, alternating in a number-letter sequence. Requirement: Rapid alternation of symbolic systems; rapid coordination of complex sequential visual identification with a simple motor response. Score: Time required to correctly complete the sequence.

Rhythm Test (Seashore, Lewis & Saetveit, 1960):

The child is required to make a judgement of "same" or "different" for each of 30 pairs of rhythmically patterned pure tones presented by tape recorder. Requirement: Discrimination of rhythmic similarity; nonverbal auditory perception; retention of pairs of sequences to make a judgement of similarity. Score: Number correct.

D. PERCEPTION

Auditory:

CELF #12:

Processing Speech Sounds: see descriptions above. Verbal auditory perception of speech sounds.

Rhythm Test: see descriptions above.

Nonverbal auditory perception.

Visual:

WISC-R Performance Subtests: see descriptions above.

Trail-making Test: see description above.

Benton Visual Retention Test (BVRT) (Benton, 1963):

Administration A: Two single figure and seven three figure designs are exposed for 10 seconds and the child is required to recall them immediately by drawing. Requirement: Memory for nonverbal meaningless visual designs; motor drawing response; visual-motor integration. Score: Number correct and number of errors summed across the designs.

Right-left Discrimination Test:

The child is required to identify his own body parts (eyes open, eyes closed) and those of a picture of a boy in terms of right-left orientation. Requirement: Spatial orientation. Score: Number of errors.

Tactile:

Finger Localization (Reitan, 1965):

The child is required to identify the finger touched by the examiner out of the child's view. The child designates which finger was touched by pointing to it with the other hand. Each finger of the dominant hand is touched four times in a specified order. The procedure is then repeated for the nondominant hand. Requirement: Tactile perception, simple recognition. Score: Number of errors with the dominant hand and number of errors with the nondominant hand.

Finger-tip Number Writing (Reitan, 1965):

The examiner draws a number on the child's finger-tip with a pencil and the child is required to identify the number on the basis of touch alone. The numbers 3, 4, 5 and 6 are drawn in random order on each finger of the dominant hand and then of the nondominant hand. Requirement: Tactile perception, simple discrimination. Score: Number of errors with the dominant hand and number of errors with the non-dominant hand.

E. MOTOR

Lateral Dominance Examination:

The child is required to demonstrate the hand used to throw a ball, etc. Requirement: Demonstration of preferred hand. Score: Total number of acts performed with the preferred hand.

Finger Tapping (Reitan, 1959):

The child is required to tap a mechanical counter as rapidly as possible with the index finger on five trials of ten seconds each. The task is performed with the dominant hand and then the nondominant hand. Requirement: Gross motor movement, rapid repetitive movement. Score: Mean number of taps per 10 seconds for the dominant hand and for the nondominant hand.

Grooved Pegboard Test (Matthews, 1977):

The child is required to insert 25 grooved pegs into a pegboard by matching the groove of the peg with the groove in the holes in the board. The task is completed with the dominant hand and then the nondominant hand. Requirement: Fine manipulative speed and coordination, speeded visual-motor cooordination. Score: Time required with the dominant hand and time required with the nondominant hand.

F. BEHAVIOUR RATINGS

Conners Teacher Questionnaire (Conners, 1969):

The teacher rates the child on 39 questions related to classroom behaviour on a scale of 0 to 4: *Not at all, Just a little, Pretty much, Very much*. The ratings are then grouped to form five scales assessing Conduct Problems, Inattentive-Passive Behaviour, Tension-Anxiety and Hyperactivity. Score: Percent on each scale.

APPENDIX C

Order Of Test Administration

APPENDIX C
ORDER OF TEST ADMINISTRATION

A. For Subjects who did not have a *WISC-R* on file:

Session 1	Session 2	Session 3
Woodcock Tests	Lateral Dominance	Knox Cube (Immed.)
WISC-R	Finger-tapping	Oral Reading Samples
	R-L Discrim.	CELF #1
	PPVT-R	CELF #4
	Trail-making	CELF #5
	Gram. Clos.	CELF #7
	Sound Blend.	CELF #9
	BVRT(memory)	CELF #10
	Finger Recog.	Grooved Pegboard
	Fingertip Number Writing	Knox Cube (Delayed)
	CELF #12	
	Edm. Spel. Abil. Test	
	BVRT (copy)	

B. For Subjects who had a recent *WISC-R* on file:

Session 1	Session 2
Woodcock tests	Tests of Session 3 from A above
Digit Span	
plus Session 2 from A above	

APPENDIX D

Oral Reading Passages[2]

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[2] The subject's copy of the passage had the type size, line length and spacing appropriate for the readability level of the passage as found in the published materials from which the passages were adapted.

APPENDIX D: Oral Reading Passages

LEVEL: PRE-PRIMER[3]
TOTAL WORDS: 279 - 14 (Joe) = 265

"I see a goat!" said Joe. "Hello, Goat! How are you? I see you. I like you. Be my goat. Dad will like you. So will Mom. Come with me."

"Dad! Dad! Look! Look! See my goat! Can I keep him? Can he stay in my room! Please!" "A goat?" asked Dad. "No! No! Not a goat! Not in the house. Goats are not clean." Dad said, "No goats for pets! Not here. Not in my house."

"Please!" said Joe. "I like him. I want to keep him. Please!" "No!" said Dad. "No! No! He is not clean. He is loud. He will break things. No goats!"

"Please!" said Joe. "I will wash him. He will be quiet. He will be careful. Please! Let him stay. Mom! Mom! Can he stay?" "No!" said Mom. "No goats".

Joe was not happy. He wanted a pet. He found a pet. It was a goat. Mom said, "No." Dad said, "No! No! No!" No goat for Joe.

Joe heard a sound. He looked around. It was a dog. A little dog! Joe patted the dog. "Hello!" Joe said. "I like you." "Bow-wow!" said the dog. "Nice dog!" said Joe. "Come with me. Be my dog. Be my pet." "Come, Dog!" said Joe. "Come with me. I'll take you home. Come! Come!"

Joe walked home. The dog walked with him. "Mom!" called Joe. "Come here. I have something. Come and see. Hurry!"

"Joe!" said Mom. "You have a dog. Who does he belong to?" "He was alone, Mom. Can I keep him? He will be a good pet." "Yes, Joe. You can keep him."

"Dog!" called Joe. "Nice dog! You are my dog."

COMPREHENSION QUESTIONS:

MAIN IDEA: What would be a good title for this story? (Joe Finds A Pet; A Pet For Joe.)

SEQUENCE: What was the first thing Joe found? (Goat.)

CAUSE-EFFECT: What did Joe say he would do because the goat was not clean? (He would wash him.)

DETAIL: Where did Joe take the dog? (Home.)

INFERENCE: How did Joe feel at the end of the story? (Happy.) Why do you say that? (He got to keep the dog.)

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[3] Source: P. C. Burns and B. D. Roe, Preprimer (A+B+C+D) in Informal Reading Assessment. Boston: Houghton-Mifflin, 1980.

LEVEL: PRIMER[4]
TOTAL WORDS: 285 - 22 (Ned, Jack) = 263

"I am happy to see you, Ned," said Jack. "I don't have a thing to do."

"A woman is coming," said Ned.

"Hello, Mrs. Little," said Jack. "Can I help you?"

"Hello, Jack," said Mrs. Little. "I want to see your mom. I want her to care for my dog."

"We can take care of your pet," said Jack. "Now we can be pet-sitters." "Yes," said Ned. "All we need are more pets".

"Look," said Jack. "Here is a pet now."

A little man with a big dog walked up.

"That's a big pet, Jack," said Ned. "Do we want a pet that big?"

"Oh, yes,"said Jack. "We take care of all pets."

"Hello," he said to the man. "Can we take care of your pet for you? We are good pet-sitters."

"That's good," said the man. "I have many things to do. Yes, you can take care of my pet."

And he walked away.

Then a big man with a little dog walked up. "Will you take care of my dog?" he said.

Jack looked at the little dog. "Oh, yes," he said. "We take care of all pets."

All day Ned and Jack took dogs. They took big dogs. And they took many little dogs.

Ned looked at the dogs. Then he looked at Jack. "We have many dogs," Ned said. "How many do we have?"

"Let's see," said Jack. "One, two, three...One, two, three...Oh, Ned. I don't know. Let's say we have fifteen dogs"

"Look, Jack," said Ned. "Here is a man with a big cat. We don't want to take care of a cat, do we?" "Oh, yes," said Jack. "We take care of all pets."

COMPREHENSION QUESTIONS:

MAIN IDEA: What were Jack and Ned doing in the story?
(Taking Care Of Pets.)

CAUSE-EFFECT: What Made Jack Happy? (Seeing Ned.)

DETAIL: How many dogs did they think they had? (Fifteen.)

SEQUENCE: What was the last pet that was brought to Jack and Ned? (A big cat.)

INFERENCE: Why might Ned not want to take care of a cat?
(Dogs don't like cats and they had many dogs; Ned thinks they have enough pets to care for.)

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[4] Source: P. C. Burns and B. D. Roe, Primer (C+A+B) in Informal Reading Assessment. Boston: Houghton-Mifflin, 1980.

LEVEL: PRIMER[5]
TOTAL WORDS: 267 - 7 (Tommy) = 260

One day Tommy saw something. He looked and looked at it. It was a seed. But what was this seed? Tommy didn't know. He put the seed in a box and went home.

"Look, Mother," he said. "I have a big seed! But what is it? Is it from a big tree? Is it from a little plant?"

Mother said, "I don't know. But you can plant the seed. Then you will find out."

Father came and looked, too. "Yes," he said. "You can plant the seed. Then you can find out what it is."

Tommy made a little hole in the earth. He put the seed in the hole. Then he put earth on the seed.

"I planted the seed," he said. Tommy asked, "Will something grow from my seed?"

Father said, "Yes, something will grow from your seed. But it needs the sun and it needs to have water, too. Water and sun help seeds grow."

Tommy looked up at the sky, and he saw the sun. He said, "It's not raining. What can we do? My seed needs rain to grow."

Father said, "You can water it. That will help your seed grow."

Tommy looked at the sky every day. It didn't rain. He said, "I don't need the rain. I will give my seed some water. I will water it every day."

One day Tommy saw something green. It was growing out of the earth. He ran in the house. He said, "My seed! My seed! Something is growing from it!"

Father laughed and said, "Good! Now your seed is a plant."

COMPREHENSION QUESTIONS:

MAIN IDEA: What would be a good title for this story? (Tommy And The Seed; The Seed Grows.)

CAUSE-EFFECT: What did Tommy do to find out what the seed was? (Planted it.)

SEQUENCE: What did Tommy do with the seed at the beginning of the story? (Put it in a box and took it home.)

DETAIL: What did the seed need to help it grow? (Sun and water, or rain.

INFERENCE: Did Tommy want the seed to grow? (Yes.) What in the story makes you answer that way? (He watered it every day.)

---

[5] Source: L. C. Fay and L. A. Cooper, Curriculum Motivation Series. Tommy Finds Out, Primer (p. 3-15.) Chicago: Lyons and Carnahan, 1967.

LEVEL: GRADE ONE[6]
TOTAL WORDS: 273 - 13 (Andy) = 260

"Wait for me!" Andy called. "Where are you going, Dan? Can I come, too?"

"I am going up to the roof," Dan said. "I have my pigeon up there."

"I wish I had a pigeon!" Andy said. "Where did you get one?"

"Mr. Day let me have one. He let me have the best pigeon. My bird is called Homer," Dan said.

"Can I see your bird?" Andy asked.

"Yes," Dan said. "You can help me feed him." They went up to the roof. Dan let Homer out of the cage. Homer flew to Dan. Andy looked at all the pigeons. Mr. Day saw Andy looking at the birds. He saw that Andy wanted a bird, too.

"Andy! Dan!" Mr. Day called. "See what I have!" Mr. Day was looking down at something.

Andy said, "There is a bird in the nest!"

Mr. Day asked, "See the egg? There is an egg in the nest, too. One day the egg will hatch"

"Will a bird come out of the egg?" Andy asked.

"Yes," Mr. Day said. "A little bird will come out of the egg. I will give the bird to you."

"Good!" Andy said. "Then I will have a bird, too."

One day, Dan and Andy went up to the roof. They looked at the egg. They wanted the egg to hatch.

"I wish I had my bird," Andy said.

Then Mr. Day saw something. "The egg is hatching now!" he said. A bird came out of the egg.

"Look! Look!" Andy called. "There is the new bird!"

COMPREHENSION QUESTIONS:

MAIN IDEA: What would be a good title for this story? (A New Pigeon; Pigeon Pets; A Pigeon For Andy.)

SEQUENCE: Where was Andy going at the beginning of the story? (Up to the roof.)

DETAIL: Where did Dan get the pigeon? (From Mr. Day.)

INFERENCE: Why did Mr. Day think Andy wanted a bird? (He saw Andy looking at the birds.)

CAUSE AND EFFECT: What happened when the egg hatched? (A bird came out.)

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[6] L. C. Fay, Curriculum Motivation Series, "The New Pigeon," in Blue Dog and Other Stories, Grade 1. Chicago: Lyons and Carnahan, 1966.

LEVEL: GRADE ONE[7]
TOTAL WORDS: 270 - 18 (Harriet, Jack, David) = 252

At last Uncle Bill and Harriet and Mom and Dad were at home. The vacation was over. Harriet was happy to be home. She wanted to play with her friends. Harriet said, "I'll go to see my friends. All of them have missed me so much. I know they all will want to see me." "That's a very good idea," said Mom. "Why don't you go see all of them?"

Harriet ran to Pat's house. She ran up to the door. Pat's mom came to see her. "Is Pat home?" asked Harriet. "He will want to see me. I have been away!" "No," said Pat's mom. "Pat is not here. He is away right now. But he didn't say he missed you."

Next Harriet went to Jack's house. She asked Jack's mom, "Are Jack and David at home? They will want to see me." "They are out playing," said Jack's mom. "I didn't know you had been away. They didn't say that they missed you."

Harriet walked away. Then she went to see her other friends. Not one of them was home. One friend was out playing. Another one was away on vacation. And one friend had moved away.

There were no friends at all. Harriet began to walk home. How sad she was. No one had missed her. She walked slower and slower. "No friends," said Harriet. "I don't have any friends." Harriet was back home. She walked into the house. "Surpirse! Surprise! Surprise!" And Harriet was surprised. There was Pat! There were Jack and David! And there were many other boys and girls! She did have friends after all!

COMPREHENSION QUESTIONS:

MAIN IDEA: When Harriet went visiting, how many friends did she find? (None.)

CAUSE-EFFECT: Why did Harriet want to see her friends? (Because she thought that they missed her.)

SEQUENCE: What was the last thing Harriet did in the story? (She walked into the house.)

DETAIL: Where were Harriet's friends: (Out playing, on vacation, moved away - accept 2 out of 3.)

INFERENCE: Where had Harriet's friends been all the time she was looking for them? (At her house.)

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[7] Source: P. C. Burns and B. D. Roe, Grade 1 (A+B) in Informal Reading Assessment. Boston: Houghton-Mifflin, 1980.

LEVEL: GRADE TWO[8]
TOTAL WORDS: 267

Peter lived in a large brick house with his grandfather, a cat, a duck, and a bird. All around the house there was a wide meadow.

Peter's grandfather had often told Peter about the wolves that lived in the forest beyond the meadow. They were large and gray and very, very mean.

"Don't go into the meadow, Peter," Grandfather would tell him. "A wolf might come out of the forest. And then, Snap! No more Peter."

Even though Peter was not very big, he wasn't afraid of anything. So one morning he got up very early. Grandfather was still asleep. Peter took his popgun and went out through the garden gate. It was a very beautiful morning.

Up in a tree, Peter's friend, the little bluebird, was singing away. "All is well! All is well! All is well!" he sang.

Peter, like all boys will do, had left the garden gate open. Soon the fat little duck followed him through the gate and into the meadow. She saw the pond. "Aha!" she thought. "What a fine place for a swim." And into the pond she went.

The bird had been watching the duck. When the duck dived into the water, the bird could not believe his eyes. He flew down for a closer look.

"Hey, you!" he called to the duck. "What are you supposed to be - some kind of a bird?"

"Of course I'm a bird!" the duck called back.

"You're no bird," the bluebird answered. "Why you can't even fly."

"What makes you think you're a bird?" the duck called. "You can't even swim".

COMPREHENSION QUESTIONS:

MAIN IDEA: Why wasn't Peter supposed to go into the meadow? (Because of the wolves.)

CAUSE-EFFECT: Why did Peter get up very early? (So he could go into the meadow without grandfather knowing it.)

INFERENCE: Why did Peter take his popgun? (So he could use it as a weapon against the wolves.)

DETAIL: Why was the duck able to follow Peter through the gate? (He had left the garden gate open.)

SEQUENCE: What did the bird do after the duck dived into the water? (He flew down for a closer look.)

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[8] Source: P. C. Burns and B. D. Roe, Grade 2 (A+B) in Informal Reading Assessment. Boston: Houghton-Mifflin, 1980.

LEVEL: GRADE TWO[9]
TOTAL WORDS: 267

The ball came fast. Dan ran to catch it. He jumped for it Swish! The ball flew past him. The game was over. Dan's team had lost.

Poor Dan. He wanted so much to play well. His baseball team was a good one. But they couldn't win games if Dan always missed the ball - and he had missed it again.

As Dan walked slowly home, he saw something on the ground. It was a baseball mitt. Dan picked it up and put it on. He walked along thinking. Why couldn't he catch the ball? He always tried so hard. Lost in thought, he threw a ball into the air and caught it. He threw the ball again, and again he caught it.

Suddenly Dan thought about what he had been doing. He threw the ball again and again. Each time it landed in his mitt. "The mitt!" he cried. "The mitt must be magic!"

The rest of the day he threw the ball into the air so that he could catch it with his magic mitt. He caught the ball just about every time.

The next day Dan got up early and worked out with the magic mitt. He couldn't wait until the game!

At last it was time to go to the ball park. A few boys were warming up when Dan got there. Dan worked out with them. He threw the ball high in the air many times. Each time he caught it with his magic mitt.

COMPREHENSION QUESTIONS:

MAIN IDEA: What was Dan's problem? (He couldn't catch the ball.)

SEQUENCE: What was the first thing Dan did in the story? (He ran to try to catch a ball and missed it.)

DETAIL: What did Dan do the rest of the day and the next morning? (He practiced catching.)

CAUSE-EFFECT: What caused Dan to be eager for the game to be played? (He was catching the ball so well he wanted the others to see.)

INFERENCE: Did Dan believe in his own ability to catch the ball? (No.) Why did you answer that way? (He thought the mitt was helping him.)

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[9] Source: P. C. Burns and B. D. Roe, Grade 2 (Example) in _Informal Reading Assessment_. Boston: Houghton-Mifflin, 1980.

LEVEL: GRADE THREE[10]
TOTAL WORDS: 250

There once was a little gray mouse who lived with his mother, all secure and snug in a haystack. As the young mouse grew up, he became more and more curious about the world that lay outside of his warm, cozy home.

One day, he approached his mother and said, "Mother, please let me go out to find our food today."

"No, my son!" she cried. "What if you should fall into the hands of our enemy?"

"Oh, mother!" exclaimed the little mouse. "I am a grown-up mouse now, and I can certainly take care of myself. Let me find our food today," he begged.

At last his mother let him go. But she made him promise to watch out for their enemy.

The young mouse ran out into the barnyard. How excited he was!

But then he saw something fearful! He saw a creature that flapped its wings and cried, "Cock-a-doodle-doo!"

The little mouse scurried back to his mother. "Mother! Mother!" he cried. "I've just met our enemy. It was a terrible creature with a comb as red as blood! Its legs and feet were yellow, and it had sharp claws. It had a great, pointed beak, and it had angry red rings around its eyes. It opened its mouth and screamed at me! It was terrible!"

The mother mouse smiled at her son. "Son, that is no enemy," she said. "That is a rooster. He looks fierce, but he is harmless. Don't be afraid of him."

COMPREHENSION QUESTIONS:

MAIN IDEA: Why didn't the mother want the little mouse to get the food? (She was afraid he would fall into the hands of the enemy.)

INFERENCE: Why did the little mouse want to be the one to find the food? (He thought he was grown up; he was curious about the outside world.)

SEQUENCE: What did the mouse's mother say first when he asked to go and find food? ("No, my son! What if you should fall into the hands of our enemy?.)

CAUSE-EFFECT: Why was the little mouse scared of the creature? (He thought it was the enemy.)

DETAIL: Who did the little mouse think the enemy was at first? (A rooster.)

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[10] Source: P. C. Burns and B. D. Roe, Grade 3 (A+B) in Informal Reading Assessment. Boston: Houghton-Mifflin, 1980.)

LEVEL: GRADE THREE[11]
TOTAL WORDS: 264 - 10 (Crandall Cricket) = 254

All during the hot weather, Crandall Cricket stayed outside. He stayed out in the woods with his fife and fiddle, having a grand time. All the other animals were busy setting by food for the winter and making warm nests for themselves. But not Crandall Cricket. One day he was fiddling for the fish to dance. The next day he was teaching the young birds how to whistle along with his fife. Day in and day out, he played and had fun until by and by, the weather began to get cooler and the days shorter.

It got so cold that Crandall Cricket had to keep his hands in his pockets. His fingers were so cold that he could hardly play. He had to put his fiddle under his arm and his fife in his pocket.

Soon Crandall could hardly walk outside unless the sun was shining. He began to get hungry, but, of course, he had not a thing to eat. And he wished that instead of fiddling and fifing, prancing and dancing, he had taken time to set by his winter food. But he hadn't, so he decided that something had to be done.

One day Crandall came to a house with smoke coming from the chimney. It was a country house made of logs and red clay. Crandall Cricket crawled under the house and close up to the chimney. He wanted to get warm. But the chimney was stone cold. He set to work, gnawing and clawing, scratching and sawing, until he could feel the warm fire.

COMPREHENSION QUESTIONS:

MAIN IDEA: What would be a good title for this story? (If You Don't Work, You Won't Eat: It's Smart To Plan For The Future)

DETAIL: What musical instruments did Crandall play? (Fife and fiddle.)

CAUSE-EFFECT: What caused Crandall to have to keep his hands in his pockets? (It got so cold it made his fingers cold.)

SEQUENCE: What did Crandall do when he came to the house? (He crawled under the house and close up to the chimney.)

INFERENCE: If Crandall had the summer to live over again, would he act the same way he did before? (No.) What did the story say to cause you to answer that way? (He wished he had taken time to store some winter food.)

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[11] Source: P. C. Burns and B. D. Roe, Grade 3 (C+D) in Informal Reading Assessment. Boston: Houghton-Mifflin, 1980.)

LEVEL: GRADE FOUR[12]
TOTAL WORDS: 268

Jim skated to the far end of the pond. He wanted to get away from everyone.

He decided to try a jump. He got up speed and leaped. But when he came down, he heard a cracking sound. The ice broke beneath him. Jim fell into the ice-cold water, with only his arms out of the water. His skates touched the soft mud on the bottom of the pond. He tried to climb out, but the ice broke away when he tried to hold on to it.

Jim called out, "Help me, someone!" Jim saw the boys at the centre of the pond turn and look. Then they came racing toward him. He felt as if he were freezing in the cold water. Soon everyone reached the far end of the pond. There was alot of shouting and moving about. Then Jim saw Ted Brooks crawling toward him. Ted had a long tree limb in his hand. Behind Ted, the other boys made a line. They lay flat on the ice, each one hanging to the legs of the boy in front.

When Ted was about six feet away, he pushed the limb toward Jim. Jim held on, and Ted began to pull. Jim's skates came out of the mud as he was pulled up over the edge of the ice. Then the ice cracked and broke away again. "Hang on!" Ted shouted. "Don't let go!" The boys behind Ted moved back, pulling as hard as they could. Jim came up over the edge again, and this time the ice held. He was out of the water!

COMPREHENSION QUESTIONS:

MAIN IDEA:What would be a good title for this story? (Rescue; Skating Accident.)

SEQUENCE: What happened when Jim first tried to climb out of the water? (The ice broke away when he tried to hold on to it.)

CAUSE-EFFECT: What caused the ice to break in the first place? (Jim tried a jump.)

DETAIL: What did the boys use to help Jim out of the water? (A long tree limb.)

INFERENCE: Why did the boys need a long tree limb to help Jim out of the water? (Because the ice would break if they went close to the hole where Jim was.)

---

[12] Source: L. C. Fay, Curriculum Motivation Series, "On Thin Ice", in The Barking Cat and Other Stories, Level 4. Chicago: Lyons and Carnahan, 1966.

LEVEL: GRADE FOUR[13]
TOTAL WORDS: 252

Peter was hanging on to the branch of the tree, yelling at Joe to come up behind him. The bank was steep, and the sand was beginning to slip away as they held on in the hot sun.

The two boys were trying to reach the top of the hill to meet their friends on the upper level. It was a good shortcut and it had been used for years. But now, there was something wrong!

Peter's feet could not find a firm hold in the sand, and he kept slipping down a little farther with each step. Now he was too close to Joe's spot just below him. Joe called to him to hang on, but he couldn't. Soon Pete's boot had pushed Joe's hand from its hold on the tree branch, and both lads tumbled downward, rolling over and over, head over heels in a cloud of dust.

When the air cleared, there was no one in sight. A few grains of sand moved; that was all. A moment or two went by before a hand pushed out from the sand and a head poked up through the surface. It was Joe. He backed out and shook himself. Then he remembered his friend. Where was Peter?

It only took three jabs with a long stick to find Pete and even less time to pull him out. Joe rolled the silent boy over onto his side and gave his back two smart slaps. Peter coughed and slowly opened his eyes.

COMPREHENSION QUESTIONS:

MAIN IDEA: What would be a good title for this story? (Landslide; Falling; The Shortcut.)

CAUSE-EFFECT: Why were the boys trying to reach the top of the hill? (To meet their friends.)

SEQUENCE: Who came out of the sand first? (Joe.)

DETAIL: What did Joe use to find Peter? (A stick.)

INFERENCE: Could Peter get out of the sand without help? (No.) What did the story say to cause you to say that? (Joe had to pull Peter out; Joe had to give Peter some slaps to wake him.)

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[13] Source: Tom Smith, Time Out Series, "Landslide", in _Landslide and Other Stories_. Canada: J. M. Dent and Son, 1973.

LEVEL: GRADE FOUR[14]
TOTAL WORDS: 265

Brent Todhill hung on to the Cessna's safety harness and took a long look down at his target on the fairgrounds below. The little plane banked, and Brent knew he had to jump. He drew a quick breath. Keeping his eyes on the tiny orange dot four thousand feet under him, he leaped out into the cool, rushing air.

His arms stretched, and his legs spread out to their widest. He kept his head high to balance himself as he drifted sideways, round and round. The air streamed past his face, and he seemed to float in the bright sky. It was a strange, free feeling and it made his blood tingle.

Time now to pull the ripcord of the parachute. Brent counted and then pulled hard. Instead of being jerked into a sitting position, he found himself still floating downward. He glanced up quickly. There was no parachute swaying above his head! All at once it seemed as if his heart jammed in his throat. He was still in a free fall! The ground was coming up to meet him, and he knew he had just seconds to go.

Brent reached down with sweaty fingers and grasped the ring of the spare chute. He gave the cord one good pull. It snapped off in his hands! In a last try, almost without hope, he reached over his shoulder and clawed at the back pack with his fingers. The pilot chute suddenly found the air, blew open, and pulled the big chute out behind it, slowing his fall just in time.

COMPREHENSION QUESTIONS:

MAIN IDEA: What sould be a good title for this story? (Skydiver; Skyjump; Faulty Parachute.)

DETAIL: Where was his target? (Fairgrounds.)

SEQUENCE: What happened when Brent first pulled the cord of the spare chute? (It snapped off.)

CAUSE-EFFECT: How did Brent finally get the chute open? (He clawed at the back pack, pilot chute opened and pulled out the big chute.)

INFERENCE: Was Brent afraid? (Yes.) What in the story makes you think so? (Heart jammed in throat; fingers were sweaty; almost without hope.)

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[14] Source: Tom Smith, Time Out Series, "Sky Diver", in Big Cat and Other Stories. Canada: J. M. Dent and Sons, 1973.

LEVEL: GRADE FOUR[15]
TOTAL WORDS: 260

A man with a gun entered the cockpit of the plane. He dropped a note into my lap. "Cuba," it read.

We might have enough fuel, but just enough. It would be risky. I decided to talk to the hijacker and, at the same time, leave the radio on full. Perhaps someone on another plane would hear us and send help.

The plan was a lucky one! Before half an hour had passed by, two jets were at our wing tips, slowing down to match our own speed. The hijacker saw them too, but he didn't seem to be upset by them.

Now we had time to think out a plan. Beside us, one of the jets cut his engine to slow speed and fell straight down. Then he zoomed up again. Twice he did this strange stunt. Then we began to understand what he wanted us to do.

Without letting the gunman know what was happening, I sent out a signal to the stewardess to "belt down" all the passengers. When she signalled back "all safe and sound", I slowly reached out for the throttles to cut down our power. Quickly the levers were back, and we almost slipped out of the sky. Our hijacker wasn't ready. He lost his hold on the back of my chair, hit the ceiling, and fell back onto the deck of the cabin. My co-pilot picked up the gun as we glided upward. Then he marched the big man back through the passenger space and into the kitchen where he could be watched.

COMPREHENSION QUESTIONS:

MAIN IDEA: What would be a good title for this story? (Hijacker.)

DETAIL: Where did the hijacker want to go? (Cuba.)

CAUSE-EFFECT: What caused the jet to fall straight down? (He cut the engine to slow speed.)

SEQUENCE: What happened to the hijacker after they slowed their engines? (He fell.)

INFERENCE: Why did the pilot signal to the stewardess to "belt down" the passengers? (So they wouldn't get hurt when the plane dropped.)

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[15] Source: Tom Smith, Time Out Series, "Hijack", in Landslide and Other Stories. Canada, J. M. Dent and Sons, 1973.

APPENDIX E

Factor Loadings Of Subjects Classified Into Four Subgroups By Q Factor Analysis Of Eleven Reading Measures, And Also Of Unclassified Subjects

APPENDIX E
FACTOR LOADINGS[1] OF SUBJECTS CLASSIFIED INTO FOUR SUBGROUPS BY Q FACTOR ANALYSIS OF ELEVEN READING MEASURES, AND ALSO OF UNCLASSIFIED SUBJECTS

	FACTOR			
S[2]	1	2	3	4
Subgroup 1				
38	83	-19	25	02
08	82	-24	-18	-12
12	77	50	33	-03
33	65	54	-20	-33
28	64	32	06	19
09	62	-61	-04	-15
18	60	-33	57	07
49	56	-62	08	-11
34	45	-58	-33	06
35	43	28	-71	14
Subgroup 2				
44	04	82	13	-08
25	29	81	27	09
45	-05	81	02	-20
17	48	80	30	07
26	-19	79	-03	-11
10	08	78	-25	-20
24	-74	77	-32	50
02	29	74	12	13
Subgroup 3				
20	13	-01	88	-15
40	-03	11	84	28
36	52	-15	69	-24
15	-78	08	54	-17
05	20	-03	52	48
Subgroup 4				
30	-05	-34	-26	86
14	29	-06	06	85
48	04	44	03	75
41	15	07	66	70
31	-23	-12	57	68
13	31	-40	30	64
29	-06	23	-06	56
22	16	-49	-54	51
16	37	-20	18	50
23	-74	09	-32	50
Unclassified				
01	-43	-24	-62	01
03	-77	-51	10	-03
04	06	03	-15	-36
06	-46	-37	07	-60
07	-84	09	-23	-33
11	22	-18	-82	-20
19	-62	17	-05	-58
21	-89	24	-17	-10
27	-51	-19	11	-32
32	-97	01	13	-03
37	27	-91	03	01
39	-84	-02	-25	-25
42	-18	-90	-01	-30
43	-76	-15	-44	-29
46	-21	-07	-64	-22
47	21	-74	21	-27

1. Decimal points are omitted.
2. Subjects are ranked according to the maginitude of the loading on the factor defining the subgroup in which they were classified (defined by factor loadings ≥ .40).

APPENDIX F

Comparisons Of Four Subgroups Formed By Q Factor Analysis Of 11 Reading Measures On The Classification Measures

APPENDIX F
COMPARISONS OF FOUR SUBGROUPS FORMED BY Q FACTOR ANALYSIS OF 11 READING MEASURES ON THE CLASSIFICATION MEASURES

MEASURES	SUBGROUPS								*F*-RATIO[1]	SCHEFFE COMPARISONS					
	1		2		3		4			1 vs 2	1 vs 3	1 vs 4	2 vs 3	2 vs 4	3 vs 4
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD							
Woodcock															
Word Ident.	59.6	11.5	76.5	3.3	75.0	5.2	68.9	9.5	6.72**	+	+				
Word Attack	73.3	11.2	80.0	6.3	88.2	8.3	74.9	5.8	4.21*		+				+
Passage Compreh.	78.6	7.0	87.1	4.2	87.8	3.6	88.9	6.0	6.50**	+	+	+			
Oral Reading Analysis															
Graphic Similarity	52.0	6.0	54.0	4.3	48.4	3.4	55.8	5.1	2.66						
Phonic Similarity	40.9	6.3	43.6	6.1	36.4	2.9	40.4	8.0	1.27						
Syntactic Accept.	57.7	7.6	66.6	6.6	57.2	7.7	52.7	6.3	5.94**	+				+	
Semantic Accept.	53.6	6.1	50.8	3.6	37.4	6.4	40.4	5.2	16.72**		+	+	+	+	
Meaning	37.8	9.1	35.5	4.0	30.2	7.7	28.3	5.2	3.92*			+			
Speed (wpm)	58.4	9.7	78.9	12.3	60.5	5.2	79.7	10.1	11.23**	+		+	+		+
Passage Compreh.	69.0	16.6	55.0	9.3	66.0	13.4	72.0	7.9	3.14*					+	
Self Corr.	29.0	12.4	13.0	4.0	22.2	8.7	28.8	7.5	6.12**	+				+	

1. Degrees Of Freedom = 3,29 for each comparison

** $p < .01$

 * $p < .05$

+ $p < .10$ For Scheffe Comparison

APPENDIX G

Comparison Of Four Subgroups Formed By Q Factor Analysis Of Eleven Reading Measures On Reading And Spelling Measures External To The Classification

APPENDIX G

COMPARISONS OF FOUR SUBGROUPS FORMED BY Q FACTOR ANALYSIS OF 11 READING MEASURES ON READING AND SPELLING MEASURES EXTERNAL TO THE CLASSIFICATION

MEASURES	SUBGROUPS 1 $\overline{X}$	1 SD	2 $\overline{X}$	2 SD	3 $\overline{X}$	3 SD	4 $\overline{X}$	4 SD	F-RATIO[1]
Oral Reading Errors									
Insertions	7.2	3.2	5.1	5.2	5.2	4.9	5.2	5.5	0.42
Omissions	11.9	7.6	12.4	8.2	14.1	6.2	14.4	11.6	0.17
Word.Ord.Rev.	2.2	2.3	0.3	0.7	1.4	1.3	0.5	0.8	3.16*[2]
Lett.Ord.Rev.	2.1	1.1	0.4	0.8	0.7	1.6	2.5	3.1	2.18
Substitutions:									
Same Stem	12.1	6.2	11.9	5.7	7.1	3.1	9.4	2.8	1.54
Same Affix	3.7	2.7	7.2	3.2	6.5	5.6	5.3	5.2	1.19
Oth. Mean.	57.8	9.1	54.0	10.7	56.1	11.7	55.7	15.4	0.15
Nonsense	3.4	3.3	7.2	5.9	9.1	6.3	7.3	7.7	1.31
Repetitions	56.8	22.7	53.3	14.3	56.6	6.7	63.3	15.1	0.57
Spelling									
Grade	2.6	0.3	3.5	0.7	2.9	0.2	3.2	0.4	7.35**[3]
Grade Disc.	2.3	0.4	1.4	0.4	1.6	0.5	1.9	0.5	6.84**[4]
% Phon.									
Acc. Err.	50.2	22.4	43.3	18.9	48.4	8.4	38.0	12.3	0.73

* $p < .05$

** $p < .01$

1. Degrees of freedom = 3,29
2. Scheffe post hoc comparisons: subgroup 1 > subgroup 2, $p < .10$.
3. Scheffe post hoc comparisons: subgroups 2 and 4 > subgroup 1, $p < .10$
4. Scheffe post hoc comparisons: subgroup 1 > subgroups 2 and 3, $p < .10$.

APPENDIX H

Comparisons Of Subgroups Formed By Q Factor Analysis Of Reading Measures On Nonreading Measures

APPENDIX H
COMPARISONS OF SUBGROUPS FORMED BY Q FACTOR ANALYSIS OF READING MEASURES ON NONREADING MEASURES

MEASURES	SUBGROUPS 1		2		3		4		F-RATIO'
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	
WISC-R:									
VIQ	97.6	7.8	94.8	8.0	99.6	12.1	100.6	9.7	0.66
PIQ	98.3	8.0	108.4	10.6	108.0	11.4	106.4	10.8	1.98
FSIQ	97.6	6.2	100.8	8.9	103.8	12.2	103.1	8.2	0.91
PIQ-VIQ	0.7	10.3	13.6	8.7	8.4	9.0	5.8	14.4	2.01
Information	9.0	2.2	8.9	2.0	9.8	2.9	10.0	1.8	0.60
Similarities	10.3	1.8	8.8	2.3	11.6	3.0	10.8	3.1	1.56
Arithmetic	9.2	1.6	8.4	2.8	8.2	2.6	8.2	1.8	0.45
Vocabulary	10.0	1.8	9.5	2.2	10.8	1.9	10.9	1.4	1.10
Comprehension	9.9	2.2	10.5	2.9	9.6	1.8	11.0	2.3	0.54
Digit Span	7.2	1.9	6.9	1.4	6.2	1.9	8.3	2.2	1.61
Pict. Comp.	10.2	3.0	11.5	1.7	13.0	1.6	11.7	2.1	1.80
Pict. Arrange.	11.2	1.9	12.3	1.3	10.2	0.8	11.8	1.9	1.79
Block Des.	10.6	2.3	10.6	3.5	11.6	3.2	10.5	3.0	0.17
Obj. Assem.	10.4	2.0	10.9	2.3	12.2	2.6	10.2	2.1	0.39
Coding	6.7	1.5	10.9	1.6	9.0	2.6	10.0	2.8	6.61**'
PPVT-R	95.0	7.4	93.0	8.3	91.8	9.5	104.8	13.3	3.01*'
Gramm. Closure	28.9	9.6	31.3	6.5	30.2	14.1	33.2	5.7	0.42
Sound Blend.	39.0	5.5	37.5	5.5	39.2	4.6	38.1	5.4	0.21
CELF:									
Word & Sent. Struc.	85.0	5.7	82.0	9.9	84.0	5.6	82.1	6.7	0.38
Relat. & Amb.	71.0	7.2	66.5	6.4	73.4	8.4	72.8	6.9	1.46
Oral Dir.	73.4	11.0	79.3	15.6	73.6	22.4	80.2	12.4	0.52
Word Series:									
Accuracy	76.3	19.2	82.3	15.4	72:8	30.7	84.8	20.0	0.52
Time	20.2	10.4	19.4	12.6	24.8	12.8	17.2	16.3	0.37
Confront. Naming:									
Accuracy	75.6	11.0	82.6	6.7	81.2	6.1	78.6	8.8	1.07
Time	90.0	24.9	85.6	14.0	99.2	29.2	85.5	19.8	0.52
Word Assn.	31.2	6.6	28.3	6.3	31.4	4.0	34.4	6.4	1.50
Model Sents.	60.4	13.8	63.5	16.2	58.0	11.1	62.0	7.0	0.23
Aud. Discr.	97.1	2.9	96.9	3.3	97.0	3.0	96.0	3.8	0.22
Fing. Rec.: Dom.	1.8	1.9	2.0	2.0	2.2	2.2	1.8	1.9	0.06
(# Errors) Non-dom	2.1	2.0	2.3	2.2	1.4	1.7	1.5	2.2	0.32
Numb. Writ.: Dom.	4.7	2.2	5.3	2.8	3.8	2.5	4.1	4.2	0.31
(# Errors) Non-dom	6.8	2.1	4.6	3.1	4.4	1.8	4.6	4.1	1.26

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APPENDIX H (Continued)
COMPARISONS OF SUBGROUPS FORMED BY Q FACTOR ANALYSIS OF READING MEASURES ON NONREADING MEASURES

MEASURES	SUBGROUPS 1 $\overline{X}$	1 SD	2 $\overline{X}$	2 SD	3 $\overline{X}$	3 SD	4 $\overline{X}$	4 SD	F-RATIO[1]
Fing. Tap.: Dom.	36.3	2.8	37.6	3.1	35.0	2.4	33.9	3.5	2.41
Non-dom	31.2	3.2	36.3	3.7	31.8	4.4	31.9	4.9	2.68
Grooved Peg.: Dom.	79.3	7.4	73.3	7.2	72.0	6.4	76.7	12.9	0.97
(Time) Non-dom.	92.2	10.8	80.9	7.7	88.0	8.2	85.1	20.9	1.03
Trail-making (Time): A	23.6	7.2	19.0	5.6	19.4	6.2	16.4	4.4	2.56
B	64.6	55.4	41.4	17.5	38.8	13.9	41.6	18.4	1.13
Rhythm Test	21.5	3.4	21.9	5.5	21.2	1.3	21.2	1.8	0.07
Knox Cube Test: Immed.	10.6	1.5	10.6	2.4	12.0	2.4	10.7	2.2	0.59
Knox Cube Test: Del.	7.4	1.9	8.9	3.0	8.8	1.1	8.8	1.9	1.04
BVRT: Memory	5.7	1.2	6.1	2.2	4.2	1.3	5.5	1.8	1.41
BVRT: Copying	8.4	1.1	8.7	1.6	6.0	2.1	7.9	1.3	4.16**
Conners:									
Conduct Prob.	7.4	17.3	1.1	2.2	17.2	16.2	6.4	17.6	1.18
Inatt.-Pass.	44.7	19.4	39.5	20.9	32.6	22.7	26.8	18.9	1.45
Tens.-Anx.	22.8	16.3	15.6	11.8	5.8	5.1	35.8	16.1	5.90**
Hyperactivity	22.9	18.2	19.5	16.7	24.6	22.5	13.9	22.5	0.47

* $p < .05$
** $p < .01$
1. Degrees of Freedom = 3,29 for each comparison.
2. Scheffe post hoc comparison: subgroups 2,4 > 1 ($p < .10$).
3. Scheffe post hoc comparisons: none significant.
4. Scheffe post hoc comparisons: subgroups 1, 2 > 3 ($p < .10$).
5. Scheffe post hoc comparisons: subgroup 4 > 3 ($p < .10$).

APPENDIX I

Comparisons Of Four Subgroups Formed By Cluster Analysis Of 11 Reading Measures On The Classification Measures

APPENDIX I
COMPARISONS OF FOUR SUBGROUPS FORMED BY CLUSTER ANALYSIS OF 11 READING MEASURES ON THE CLASSIFICATION MEASURES

MEASURES	S U B G R O U P S								*F*-RATIO[1]	SCHEFFE COMPARISONS					
	1		2		3		4			1 vs 2	1 vs 3	1 vs 4	2 vs 3	2 vs 4	3 vs 4
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD							
Woodcock															
Word Ident.	54.73	10.98	73.83	6.09	75.39	4.33	71.62	5.64	21.17**	+	+	+			
Word Attack	75.27	13.71	79.67	6.05	92.54	12.13	79.39	7.46	6.67**		+		+		+
Passage Compreh.	73.91	5.43	85.33	5.35	85.77	8.17	88.69	4.82	13.02**	+	+	+			
Oral Reading Analysis															
Graphic Similarity	56.0	5.76	52.92	4.62	63.54	7.11	51.62	5.11	11.12**		+		+		+
Phonic Similarity	41.18	3.57	43.25	6.03	53.15	5.44	36.77	5.45	22.48**		+		+	+	+
Syntactic Accept.	51.36	5.52	65.00	6.98	56.31	7.09	55.77	7.53	8.06**	+			+	+	
Semantic Accept.	44.73	9.11	52.25	5.51	32.39	5.75	41.77	6.10	18.92**	+	+		+	+	+
Meaning	28.0	8.69	39.08	6.89	22.00	6.26	31.23	3.32	15.10**	+			+	+	+
Speed (wpm)	52.36	11.10	75.79	11.44	71.69	13.75	71.23	10.71	8.85**	+	+	+			
Passage Compreh.	68.18	20.41	55.00	11.68	47.69	16.41	72.31	9.27	7.49**		+			+	+
Self Corr.	33.82	9.50	16.00	9.14	20.77	8.24	29.31	9.48	9.29**	+	+			+	

[1] Degrees Of Freedom = 3,45 For Each Comparison

** $p < .01$

* $p < .05$

+ $p < .10$ For Scheffe Comparison

APPENDIX J

Comparisons Of Subgroups Formed By Cluster Analysis Of Reading Measures On Reading And Spelling Measures External To The Classification

APPENDIX J

COMPARISONS OF SUBGROUPS FORMED BY CLUSTER ANALYSIS OF READING MEASURES ON READING AND SPELLING MEASURES EXTERNAL TO THE CLASSIFICATION

MEASURES	SUBGROUPS								F-RATIO¹	SCHEFFE COMPARISONS					
	1		2		3		4			1 vs 2	1 vs 3	1 vs 4	2 vs 3	2 vs 4	3 vs 4
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD							
Oral Reading Error Types															
Insertions	5.14	3.70	5.21	4.29	4.42	3.97	5.92	4.95	0.27						
Omissions	7.05	5.98	12.54	7.19	9.65	5.49	15.81	10.00	3.33*			+			
Repet.	64.35	15.31	49.38	17.46	58.64	15.50	63.11	12.84	2.34						
Word Rev.	0.59	.86	1.00	1.69	0.73	1.23	1.27	2.01	0.47						
Letter Rev.	3.46	2.32	0.75	0.94	1.15	2.30	1.77	2.59	3.52*	+	+				
Substit: Stem	9.86	5.32	13.42	6.37	12.00	4.85	8.69	2.88	2.25						
Affix	4.55	2.36	6.21	3.41	8.96	4.98	4.58	4.69	3.31*		+				+
Other Meaningful	64.18	9.79	52.50	9.05	44.65	6.98	56.50	13.57	7.68**	+	+				+
Nonsense	5.41	4.67	6.17	5.13	18.54	8.31	5.69	5.61	13.67**		+		+		+
Spelling Grade	2.62	0.26	3.38	0.77	3.43	0.73	3.20	0.33	4.78**	+	+				
Discrep.	2.22	0.65	1.62	0.55	1.68	0.81	1.79	0.39	2.19						
%Phon.Acc.	50.09	20.11	47.83	19.36	57.54	22.21	46.00	18.00	0.83						

1. Degrees Of Freedom = 3,45 for each comparison
* $p < .05$
** $p < .01$
+ $p < .10$

APPENDIX K

Comparisons Of Subgroups Formed By Cluster Analysis Of Reading Measures On Nonreading Measures

APPENDIX K
COMPARISONS OF SUBGROUPS FORMED BY CLUSTER ANALYSIS OF READING MEASURES ON NONREADING MEASURES

MEASURES	SUBGROUPS 1 $\bar{X}$	1 SD	2 $\bar{X}$	2 SD	3 $\bar{X}$	3 SD	4 $\bar{X}$	4 SD	F-RATIO[1]
WISC-R:									
VIQ	96.1	9.4	95.9	7.2	93.2	7.6	101.7	9.7	2.24
PIQ	100.0	5.4	102.6	12.0	105.7	8.2	107.7	11.3	1.45
FSIQ	97.4	7.0	98.5	8.0	98.7	7.2	104.5	9.1	2.09
PIQ-VIQ	3.9	8.7	6.7	12.9	12.5	8.1	6.0	1.4	1.35
Information	8.5	2.4	8.8	1.7	8.2	1.9	10.2	2.0	2.33
Similarities	9.9	2.0	9.3	2.0	8.9	1.3	11.8	2.6	5.04**[1]
Arithmetic	9.1	1.8	8.6	2.6	9.0	2.9	8.4	2.0	0.25
Vocabulary	10.3	2.2	9.9	1.9	9.0	1.9	11.0	1.4	2.59
Comprehension	9.4	2.2	10.5	2.7	9.6	2.1	10.5	2.3	0.75
Digit Span	6.6	2.3	7.2	1.4	9.2	3.2	7.5	2.1	2.61
Pict. Comp.	10.4	2.2	10.4	2.6	11.0	2.3	12.3	2.2	1.89
Pict. Arrange.	10.9	2.3	11.5	1.7	11.2	3.0	11.8	1.8	0.33
Block Des.	9.9	2.1	10.5	2.9	10.6	1.7	11.3	3.2	0.62
Obj. Assem.	11.5	1.4	10.2	2.2	11.2	2.4	10.8	2.4	0.76
Coding	7.5	1.0	9.5	2.5	10.4	1.7	9.3	3.2	3.34*[1]
PPVT-R	92.5	11.3	94.3	8.6	90.9	10.8	101.2	11.6	2.37
Gramm. Closure	30.0	6.5	31.0	8.6	31.6	7.9	31.1	9.2	0.08
Sound Blend.	39.1	3.4	38.2	4.9	38.8	4.6	39.2	4.4	0.13
CELF:									
Word & Sent. Struc.	84.4	7.4	82.6	8.6	81.1	7.5	82.8	6.3	0.39
Relat. & Amb.	70.0	7.0	68.0	7.3	74.2	8.6	74.8	7.0	2.35
Oral Dir.	77.5	13.1	77.3	14.1	79.5	10.7	74.3	15.3	0.33
Word Series:									
Accuracy	78.5	17.4	81.6	17.6	74.5	24.3	85.5	22.2	0.66
Time	17.2	11.1	18.3	10.6	20.0	8.1	19.4	16.1	0.13
Confront. Naming:									
Accuracy	81.0	9.3	79.4	10.0	81.7	9.3	81.0	6.9	0.14
Time	86.8	26.1	84.6	12.7	71.6	16.6	91.7	23.8	2.28
Word Assn.	31.1	8.2	30.3	6.0	33.2	7.5	32.9	5.6	0.50
Model Sents.	58.3	14.4	65.1	15.0	62.9	12.7	62.5	8.1	0.57
Aud. Discr.	97.5	2.4	96.8	3.0	98.3	1.7	96.0	3.6	1.59
Fing. Rec.: Dom.	1.1	1.1	2.1	2.1	0.8	1.1	2.1	2.0	2.10
(# Errors) Non-dom	2.2	1.7	2.2	2.2	1.2	1.1	1.5	2.1	0.94
Numb. Writ.: Dom.	4.5	2.3	5.1	2.8	4.0	3.5	4.0	3.6	0.33
(# Errors) Non-dom	5.5	2.9	5.2	2.8	3.8	2.5	5.0	3.3	0.82
Fing. Tapp.: Dom.	36.9	3.1	37.8	2.7	34.9	4.3	34.2	3.3	2.86*[1]
Non-dom	32.4	3.6	34.7	3.9	31.9	4.3	32.4	4.6	1.13

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APPENDIX K (Continued)
COMPARISONS OF SUBGROUPS FORMED BY CLUSTER ANALYSIS OF READING MEASURES ON NONREADING MEASURES

MEASURES	SUBGROUPS 1		2		3		4		*F*-RATIO[1]
	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	
Grooved Pegb.: Dom.	75.3	9.9	77.5	10.4	72.0	9.8	76.2	11.6	0.65
(Time) Non-dom.	85.0	14.5	85.8	9.9	83.8	11.6	86.9	18.1	0.11
Trail-making (Time): A	23.7	10.2	19.6	5.2	15.9	3.7	18.3	6.0	2.98*[1]
B	52.4	20.0	55.7	53.0	46.9	15.7	37.8	14.0	0.86
Rhythm Test	21.1	3.1	22.3	4.6	21.5	3.7	21.7	1.9	0.86
Knox Cube Test: Immed.	11.5	1.4	10.3	2.1	11.7	2.4	10.5	2.0	1.41
Knox Cube Test: Del.	8.6	2.0	8.4	2.7	9.8	2.4	8.3	1.4	1.38
BVRT: Memory	5.5	1.5	5.9	1.8	5.3	1.8	5.0	1.6	0.63
BVRT: Copying	8.3	1.1	8.5	1.3	7.9	1.5	7.3	1.7	1.63
Conduct Prob.	3.4	5.7	6.2	15.9	12.2	17.8	11.5	18.3	0.90
Inatt.-Pass.	34.5	18.0	43.1	18.9	38.8	20.7	31.9	21.0	0.77
Tens.-Anx.	18.3	13.9	23.2	18.8	31.7	27.0	25.2	18.2	0.90
Hyperactivity	14.6	13.4	22.7	18.9	24.1	22.9	18.0	23.6	0.55

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1. Degrees of Freedom = 3,45 for each comparison
2. Scheffe post hoc comparisons: subgroup 4 > 2, 3 ($p < .10$).
3. Scheffe post hoc comparisons: subgroup 3 > 1 ($p < .10$).
4. Scheffe post hoc comparisons: none significant.
5. Scheffe post hoc comparisons: subgroup 1 > 3 ($p < .10$).

APPENDIX L

Comparisons Of Subgroups Formed By Cluster Analysis Of Nonreading Factors On Nonreading Measures

APPENDIX L

COMPARISONS OF SUBGROUPS FORMED BY CLUSTER ANALYSIS OF NONREADING FACTORS ON NONREADING MEASURES

MEASURES	SUBGROUPS 1		2		3		4		5		F-RATIO'
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	
WISC-R											
VIQ	104.4	6.8	94.5	8.5	91.0	4.1	100.3	8.5	90.9	6.9	7.74**
PIQ	112.2	6.3	102.2	10.2	98.6	6.8	91.0	0.8	104.4	8.2	8.05**
FSIQ	108.3	5.6	97.4	7.5	93.8	4.0	95.3	4.6	97.0	6.2	11.5**
PIQ-VIQ	7.8	9.1	7.7	12.8	7.6	8.1	-9.3	9.2	13.6	9.8	3.48*
Information	10.3	1.6	8.5	1.5	7.4	1.4	9.8	1.7	8.3	2.9	3.89**
Simililarities	11.0	2.6	9.4	2.1	8.9	1.6	11.8	2.2	9.3	1.7	2.51*
Arithmetic	10.3	2.2	8.9	2.4	8.0	2.2	6.8	0.5	7.6	1.5	3.98**
Vocabulary	11.3	1.6	9.5	2.3	9.5	1.3	11.3	1.0	8.8	1.6	4.11**
Comprehension	11.1	2.1	9.6	2.4	9.1	2.0	11.0	2.9	9.1	2.1	1.81
Digit Span	8.5	2.1	7.6	2.2	9.3	3.4	6.0	1.2	5.8	1.5	3.62*
Picture Compl.	11.9	2.6	10.3	2.5	10.9	1.8	10.0	3.6	11.4	1.6	1.02
Pic. Arr.	12.7	1.9	11.3	2.3	9.3	2.6	10.8	1.0	11.3	1.3	3.96**
Block Design	12.1	2.5	10.9	2.7	9.3	1.9	8.5	2.1	9.8	1.5	3.64*
Object Assembly	12.1	2.2	10.5	2.2	9.8	2.2	8.8	0.5	11.3	1.2	3.37*
Coding	10.2	2.7	8.5	2.3	9.6	1.9	6.0	1.2	9.7	2.0	3.17*
PPVT-R	102.2	10.4	92.7	7.7	87.6	5.2	106.0	16.4	86.9	6.5	7.31**
Grammatic Closure	34.1	5.1	26.8	8.3	34.6	4.1	38.8	2.2	25.0	9.1	5.84**
Sound Blending	39.7	4.8	37.3	4.5	42.1	2.8	39.0	3.9	36.3	1.8	2.95*
CELF:											
Word & Sent. Structure	84.2	3.9	80.9	9.4	78.8	8.9	87.0	5.0	84.0	7.0	1.38
Relationships & Ambiguities	75.9	7.3	68.5	8.3	74.6	8.3	72.3	7.6	67.6	3.4	2.89*
Oral Direction	83.7	9.9	80.5	10.7	80.3	12.4	64.5	6.6	64.2	12.7	6.32**
Word Series:											
Accuracy	85.3	17.8	87.5	14.6	84.1	16.6	72.3	32.1	60.3	20.1	3.62*
Time	15.9	7.7	16.3	9.9	14.6	8.3	28.5	23.6	26.6	11.1	2.71*
Confront. Naming											
Accuracy	83.6	8.0	78.3	11.0	81.0	6.8	75.0	3.5	82.1	8.3	1.18
Time	77.5	10.9	86.1	10.2	64.6	12.1	114.5	34.5	93.0	27.2	6.68**
Word Association	36.9	7.2	27.1	5.7	30.8	5.7	35.5	1.7	30.2	3.2	5.84**
Model Sentences	67.3	8.5	63.5	9.0	70.8	10.4	63.5	13.3	44.1	6.5	12.10**
Auditory Discrimination	97.3	2.2	96.6	3.6	97.4	3.2	96.0	3.7	97.9	2.1	0.44
Finger Recognition											
Dominant	0.9	1.0	1.0	1.4	1.0	1.3	3.3	2.8	2.9	1.8	4.33**
Nondominant	1.4	1.2	1.2	1.7	1.1	1.5	3.5	2.6	2.8	2.0	2.61*

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APPENDIX L (Continued)

COMPARISONS OF SUBGROUPS FORMED BY CLUSTER ANALYSIS OF NONREADING FACTORS ON NONREADING MEASURES

MEASURES¹	SUBGROUPS										F-RATIO¹
	1		2		3		4		5		
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	
Number Writing											
Dominant	3.3	1.9	5.2	2.8	2.0	3.0	6.3	5.1	6.3	2.6	3.98**
Non-dominant	4.2	1.8	5.2	3.6	3.0	2.1	8.3	3.0	5.4	2.6	2.96*
Finger Tapping											
Dominant	36.5	2.6	36.1	3.7	34.8	4.2	34.5	5.2	36.2	4.2	0.45
Non-dominant	33.3	4.2	34.1	4.8	32.8	3.4	31.0	2.7	31.0	4.1	0.44
Pegboard											
Dominant	72.1	9.0	77.0	11.4	74.1	10.2	83.5	14.8	75.0	8.2	1.12
Non-dominant	80.7	10.3	87.7	10.3	80.0	9.2	101.3	26.2	87.6	14.6	2.58*
Trail-making: A	14.7	2.3	22.4	8.8	16.4	4.4	25.2	2.9	21.9	7.5	4.91**
Trail-making: B	40.8	16.8	44.1	20.2	45.4	15.9	95.5	80.9	46.0	16.3	3.42*
Rhythm	21.7	2.5	23.0	1.8	21.8	4.8	23.0	2.5	19.1	4.4	2.14
Knox: Immediate	11.7	1.8	9.6	2.0	11.8	1.6	8.8	0.5	12.1	1.7	5.39**
Knox: Delayed	10.1	1.8	7.1	1.4	10.6	2.6	7.8	0.5	8.0	1.1	8.68**
BVRT:											
Memory (#correct)	5.8	1.7	4.5	1.6	5.8	1.6	4.8	1.2	6.0	1.7	1.70
Copying (#correct)	8.2	0.8	8.6	1.0	7.6	1.5	6.0	2.4	7.9	1.8	3.12*
Conners:											
Cond. Prob.	10.2	13.6	6.6	15.1	5.5	15.6	23.0	26.6	5.0	12.8	1.17
Inattentive-Passive	27.1	15.2	45.8	16.1	30.4	18.0	50.3	13.7	40.9	26.6	2.70*
Tension-Anxiety	25.3	17.6	28.2	14.4	31.1	33.3	27.3	26.5	12.8	11.9	1.11
Hyperactivity	16.1	16.1	25.6	21.9	11.3	16.1	37.8	26.4	15.0	20.8	1.69

* $p < .05$
** $p < .01$
1. Degrees of freedom = 4,44 for each comparison. Results of Scheffe post hoc comparisons for measures where differences were significant are presented in Appendix M.

APPENDIX M
Results Of Scheffe Multiple Comparisons Comparing Subgroups Formed By Cluster Analysis Of Nonreading Factors On Nonreading Measures

APPENDIX M
RESULTS OF SCHEFFE MULTIPLE COMPARISONS COMPARING SUBGROUPS FORMED BY CLUSTER ANALYSIS OF NONREADING FACTORS ON NONREADING MEASURES

MEASURES'	SUBGROUPS COMPARED									
	1 vs 2	1 vs 3	1 vs 4	1 vs 5	2 vs 3	2 vs 4	2 vs 5	3 vs 4	3 vs 5	4 vs 5
WISC-R										
VIQ	+	+		+						
PIQ	+	+	+							
FSIQ	+	+	+	+						
PIQ-VIQ			+			+				+
Information		+								
Similarities										
Arithmetic			+	+						
Vocabulary				+						
Digit Span									+	
Picture Arrangement		+								
Block Design		+								
Object Assembly			+							
Coding			+							
PPVT-R		+		+			+			+
Gramm. Closure	+			+		+			+	+
Sound Blending									+	
CELF										
Rel. & Amb.										
Oral Direction			+	+			+		+	
Word Series:										
Accuracy				+		+	+			
Time										
Confrontation Naming										
Time			+					+	+	
Word Assoc.	+									
Model Sent.				+			+		+	+
Finger Recognition										
Dominant										
Non-Dominant				+						
Number Writing										
Dominant									+	
Non-dominant								+		

CONTINUED...

APPENDIX M (Continued)

RESULTS OF SCHEFFE MULTIPLE COMPARISONS COMPARING SUBGROUPS FORMED BY CLUSTER ANALYSIS OF NONREADING FACTORS ON NONREADING MEASURES

MEASURES[1]	SUBGROUPS COMPARED									
	1 vs 2	1 vs 3	1 vs 4	1 vs 5	2 vs 3	2 vs 4	2 vs 5	3 vs 4	3 vs 5	4 vs 5
Trail-making: A	+		+							
Trail-making: B			+			+		+		+
Knox: Immediate	+		+				+			+
Knox: Delayed	+			+	+				+	
BVRT: Copy										
Conners: Inattent.-Passive			+			+				

1. Scheffe post hoc comparisons are reported for measures with significant *F*-ratios presented in Appendix L.

+ *p* < .10

APPENDIX N

Comparisons Of Subgroups Formed By Cluster Analysis Of Nonreading Factor Scores On Reading And Spelling Measures

APPENDIX N
COMPARISONS OF SUBGROUPS FORMED BY CLUSTER ANALYSIS OF NONREADING FACTOR SCORES ON READING AND SPELLING MEASURES

MEASURES	SUBGROUPS 1 $\overline{X}$	SUBGROUPS 1 SD	SUBGROUPS 2 $\overline{X}$	SUBGROUPS 2 SD	SUBGROUPS 3 $\overline{X}$	SUBGROUPS 3 SD	SUBGROUPS 4 $\overline{X}$	SUBGROUPS 4 SD	SUBGROUPS 5 $\overline{X}$	SUBGROUPS 5 SD	F-RATIO[1]
Woodcock											
Word Identification	70.3	9.7	70.7	6.3	71.1	10.1	71.0	8.3	63.6	16.8	0.83
Word Attack	83.2	7.5	83.5	8.5	86.8	17.7	75.5	3.1	76.7	16.8	1.17
Passage Comprehension	84.7	11.1	81.8	5.0	86.1	6.4	86.0	5.9	81.9	8.6	0.58
Spelling											
Grade	3.2	0.5	3.2	0.6	3.5	0.9	2.9	0.5	2.9	0.7	1.20
Grade Discrepancy	1.9	0.5	1.9	0.6	1.7	0.9	2.0	0.6	1.6	0.7	0.51
% Phonetic Accuracy	53.3	19.3	51.8	24.1	50.3	11.4	50.3	14.4	40.7	22.8	0.68
Oral Reading											
Graphic Similarity	55.6	7.4	56.0	6.5	59.9	6.3	48.8	2.9	56.9	9.3	1.66
Phonic Similarity	43.3	7.3	42.4	8.4	49.4	7.8	37.5	7.9	44.0	7.4	1.81
Syntactic Accept.	54.1	7.5	57.6	8.5	59.4	9.5	59.0	9.9	58.9	7.7	0.79
Semantic Accuracy	37.6	6.9	46.8	8.8	39.5	8.2	51.0	12.5	43.3	11.5	3.00*[2]
Meaning	27.7	5.9	30.8	10.1	27.1	7.9	41.8	9.6	29.9	8.9	2.56*[3]
Speed (wpm)	69.4	16.1	69.5	19.7	71.8	8.7	67.1	5.6	61.8	8.5	0.61
Passage Comp.	70.7	14.4	62.3	15.3	45.0	20.0	65.0	10.0	53.3	15.8	4.12**[4]
Self-correction	26.9	10.8	29.8	13.6	21.2	6.6	20.4	9.9	19.2	9.4	1.84
Letter Reversal	2.0	3.0	1.9	1.9	1.4	2.5	2.4	0.9	1.1	2.2	0.31
Word Reversal	0.6	1.0	1.0	1.9	0.8	1.4	2.1	2.5	0.8	1.0	0.81
Insertions	4.9	3.5	6.6	5.1	3.0	3.4	6.3	3.8	4.9	5.0	1.02
Omissions	10.4	8.7	13.2	8.8	9.4	3.7	21.6	6.8	9.1	5.6	2.44
Same Stem	9.8	4.1	13.6	7.3	11.1	4.1	9.1	3.0	9.9	4.1	1.19
Same Affix	7.3	4.6	4.0	3,7	8.4	5.4	3.0	2.7	6.7	2.5	2.42
Mean. Subs.	54.0	11.8	55.3	13.7	52.6	14.6	51.8	9.3	54.9	11.3	0.98
Nonsense	11.1	7.8	4.7	4.8	12.9	8.4	3.8	2.2	11.6	11.4	2.46

1. Degrees of freedom = 4,44 for each comparison
2. Scheffe post hoc comparisons: None significant
3. Scheffe post hoc comparisons: Subgroup 4 > 1 and 3 ($p < .10$).
4. Scheffe post hoc comparisons: Subgroup 1 > 3 ($p < .10$).